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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT, 1924-25, R. O. Patterson, Blaydon-on-Tyne.

LIST OF SECRETARIES—

General Secretary: W. G. Hollinworth, 38, Victoria Street, London, S.W.1.

Lancashire: T. Makemson, 21, Beresford Road, Gorse Hill, Stretford, Manchester.

Birmingham: H. James Roe, 33, Herbert Road, Bearwood, Birmingham.

Sheffield: R. Village, Albion Foundry, Whittington Moor, near Chesterfield.

Scottish: J. Bell, 60, St. Enoch Square, Glasgow.

London: H. G. Sommerfield, Charterhouse Chambers, Charterhouse Square, London, E.C.1.

Newcastle-on-Tyne: Colin Gresty, 93, Queen's Road, Monkseaton, Northumberland.

East Midlands: H. Bunting, 17, Marcus Street, Derby.

West Riding of Yorkshire Branch: A. Love, 232, Gladstone Street, Bradford.

Wales and Monmouth Branch: J. J. McClelland, M.I.Mech.E., Druslyn, Bishops Road, Whitechurch, Glam.

Welsh Engineers' and Founders' Association.

Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

Foundry Trades Equipment & Supplies Association

Secretary: K. S. Bridges, Avenue Chambers, Southampton Row, London, W.C.1.

The Glasgow Conference.

There are but two aspects from which one can judge a technical conference. They are the social side and information made available for the individual members, and so to the industry represented. Mr. Cameron, the newly-elected President, was extremely fortunate in respect to the former, for he had the dual advantage of an extremely efficient and hard-working committee in Messrs. Bell, Affleck and Campion, and brilliant weather. Mr. Bell, on whom the major portion of the work fell, realised that when organising for workers in metals, elasticity is the first essential; thus latecomers were absorbed into the functions arranged with a minimum of trouble.

The visits arranged for the ladies were admirably organised and much appreciated, whilst the whole-day excursion by steamer round the Kyles of Bute was an unqualified success. The municipalities of both Glasgow and Falkirk accorded civic receptions to the Institute, functions which were much appreciated.

To judge the value of technical papers, a division into three categories is advisable. In the first class is placed those embodying original research, in the second, theses which correlate and expound upon their own previous work and the findings of others, whilst the third are papers of a revisionary character and contain matter which is largely covered by the standard textbooks. Of the seven papers, we would place two in the first category and the balance in the second.

The Paper which received the most comment was that of Mr. H. J. Young on "Perlit" cast iron. Though he has only been working upon this material for a few weeks, we believe he has discovered a factor which may materially help in a clearer conception of the mechanism of the process. He showed that when following this process there appeared a "hesitation" or a "perturbation" of a much greater magnitude at about 1,100 deg. C. than when pursuing normal methods. The progress of this process will be followed with more than usual interest by the foundrymen of the world. A separate session for non-ferrous foundry work was a successful innovation, and one which is worth regular incorporation.

The works' visits, of which there were four, were of special interest. In Falkirk there is a unique combination of the obsolete and the ultra-modern. It is perhaps the only town in Great Britain where foundry work is recognised as the predominant industry.

The Institute is to be congratulated in having secured Mr. John Cameron as President. Mr. Cameron is one of the most prominent of Scottish ironfounders, who has considerable interests in India, and no doubt he will use his great influence in Indian foundry circles to strengthen the position of the Institute in that country, if not actually to create a branch there. As Junior Vice-President, the Institute has been fortunate in securing the services of Mr. Goodwin, of Sheepbridge, who is best known for the sterling work he has done in connection with the British Cast Iron Research Association.

To Mr. Cameron, the members of his reception committee, the Lord Provost of Glasgow, the Provost of Falkirk, the directors of the companies who threw open their works for inspection, and to the firms who offered hospitality, we, on behalf of the foundry industry of Great Britain, offer sincere thanks. They have made an effort which it will be difficult for those who follow to emulate.

XUM

THE INSTITUTE OF BRITISH FOUNDRYMEN.

Glasgow Annual Convention.

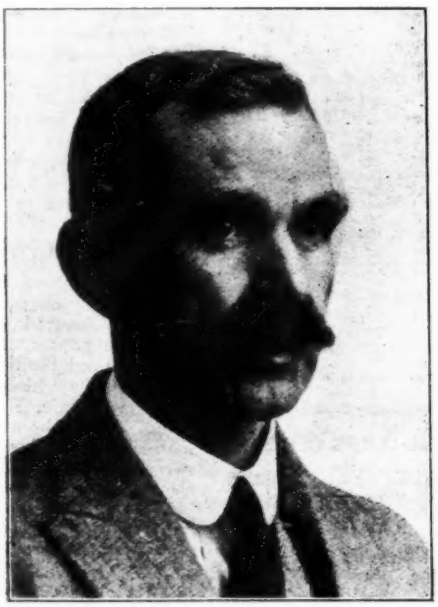
The twenty-second annual convention of the Institute was held in Glasgow from Tuesday, June 9, to Friday, June 12. The business of the Convention opened on June 10 at the Institute of Engineers and Shipbuilders in Scotland, Elmbank Crescent, Mr. R. O. Patterson, the retiring president, presided, and there were a large number of members and visitors present.

Civic Welcome.

The President, in introducing the proceedings, said he was sorry to have to announce that Lord Provost Montgomery, the civic head of the city, had been called away to London in connection with municipal business. In his absence, however, he had pleasure in calling upon Bailie Angus McDougall to extend greetings to the members attending the Convention.

Bailie McDougall, who was cordially received, explained at the outset that the Lord Provost of the city had been summoned to London in connection with the Glasgow Boundaries Bill. As business men, they would, in the circumstances, appreciate the fact that the subordinate ought to do his best in the absence of the chief. That, therefore, was his duty that morning. It was his privilege to extend to them a hearty welcome to the city of Glasgow. At the moment it was not his intention to deliver anything in the nature of a speech, because later in the day he would, he hoped, be speaking to them at the reception in the City Chambers.

Lord Invernairn, on behalf of the Glasgow Reception Committee, extended a formal welcome to the delegates. He explained that the Glasgow Committee had endeavoured to arrange for those attending the Convention an interesting as well as an instructive programme. The social aspect had not been overlooked, and, indeed, it had been the earnest desire of the Reception Committee to return, in some small measure at least, the hospitality which the Scottish members of the Institute had at all times received when attending similar conferences in England. From the information placed at his disposal he understood that the Institute had met in Glasgow on three previous occasions, namely, 1905, 1911 and 1920. Since the last annual conference was held in Glasgow the Institute had been incorporated by Royal Charter. While he did not propose to trespass upon their time and patience, he should like to say that meetings of this kind, where an exchange of views was encouraged, had a value both important and far-reaching. In their own industry, as well as others, it seemed to him to be one of the essential roads to success. Members of the Institute—at least so far as Scotland was concerned—were representative of Scottish foundry practice and engineering, and he noticed that visits were to be paid to the works of the Carron Company, the Falkirk Company and the establishments of Messrs. Babcock & Wilcox and Messrs. Weir, of Cathcart. These were firms who were known throughout the world. Proceeding, Lord Invernairn went on to say that the success of the initial annual congresses had been such as to lead to a demand for extended opportunities for the further acquisition of practical and scientific knowledge. It had resulted in the formation of local sections not only in Glasgow, Paisley and Falkirk, but in all large centres of the iron industry in England. At these places branch meetings were regularly held. It was very pleasing to reflect that the Institute of British Foundrymen was taking a forward part in bringing about an international spirit among foundrymen in Great Britain, America, France, Italy, Spain, etc. They of the Reception Committee and the Institute in Glasgow were glad to have the delegates with them, and their one wish was that the visit should prove not only beneficial, but interesting.



Mr. John Cameron (President).

Mr. John Cameron is managing director of Messrs. Cameron & Roberts, Limited, of Kirkintilloch, and a director of Eastern Light Castings, Limited, of Bengal, India. He is also a member of Council of the British Cast Iron Research Association.

Colonel J. A. Roxburgh, on behalf of the Glasgow Chamber of Commerce, joined in the greetings of the members of the Convention. Glasgow, it was well known, seemed to be a magnet that drew conferences of every conceivable kind to its midst, and the Chamber of Commerce in Glasgow, whom he represented, was always delighted to welcome to the city any body of men or women who had anything to do with trades and industries or who were working in any way whatever for the good of the country. He need not remind the members of the Convention that the particular industry in which they were interested had been and still was in a very depressed condition. It did seem to him, however, that the very fact of the industry being so depressed was a justification for the present Convention. It ought to encourage them to pursue the line they were taking in order to get their processes and their organisation more perfect than they had ever been before. Some of them he was afraid when they got into low spirits were apt to take rather a pessimistic view of the future as regards the industries of the country, but he was sure they would agree with him in saying that they did not feel the last days of Great Britain had come as yet. Personally, he was confident they would pull through this trouble as they had got through other troubles. In the meantime, however, it behoved them all to work together, both from the side of the employers and that of the employees. On behalf, therefore, of the Glasgow Chamber of Commerce and the manufacturers of the neighbourhood, he welcomed the delegates to the city. He hoped the meetings would be both pleasant and profitable and that they would go away with a good impression of Glasgow.

Professor A. L. Mellanby, D.Sc., Royal Technical College, Glasgow, humorously remarked that the members had his sympathy in being subject to the disciplinary process of listening to so many speeches. It seemed to be inevitable that before the members could enjoy the delights of Glasgow and district they should be subjected to the par-

ticular ordeal known as speech-making. Already a welcome had been extended to them from the business men of Glasgow, but he (Professor Mellanby) was there that day representing the scientific, technical and educational side of the city. That side of Glasgow would prove equally demonstrative, and it would extend as hearty a reception to the members of the Convention as had already come from the more practical business men. If, however, they had the feeling that by coming to the city they were going to derive some additional excitement, he was afraid they would be rather disappointed. On behalf of the body he represented he welcomed the delegates, and he trusted they would all have a happy and prosperous visit.

The Oliver Stubbs Medal.

THE PRESIDENT remarked that it was now his pleasant duty to ask Lord Invernairn to present the Oliver Stubbs medal to Mr. A. Campion. The Council on the previous evening had selected Mr. Campion for that distinction.

LORD INVERNAIRN said he had been asked by the Institute to make this presentation, and it was an honour which he personally highly appreciated. It was now well known in the industry that the Oliver Stubbs medal was presented for meritorious service rendered on behalf of the Institute of British Foundrymen, and it was felt that the present recipient (Mr. Campion) was well worthy the distinction.

MR. CAMPION said he was deeply appreciative of the high honour the Institute had conferred upon him. He was now beginning to wonder if the honour was at all deserved. Anything he had been able to do either for the Institute or the foundry trade in general had been work that he really loved. He had always been fascinated by foundry trade problems, and he hoped he would continue to be so for many years to come. Indeed, if he could assist the Institute in any way or could benefit the industry in any particular direction he would be pleased to do so.

THE PRESIDENT at this stage of the proceedings remarked that they were deeply grateful to all the civic and other dignitaries who had joined in the welcome that morning. They had now, however, completed the first part of the programme.

The Year's Bereavements.

The minutes of the last annual meeting having been read by the acting secretary, the President mentioned the names of those who had died during the past twelve months. As a tribute to the memory of those who had gone the delegates stood in their places.

ANNUAL REPORT AND BALANCE SHEET.

For the Session 1924-1925.

The General Council have pleasure in presenting to the members their report of the progress and work of the Institute during the past Session, 1924-25.

Three General Council meetings have been held during the Session at York, York and Sheffield respectively. Representatives of the Branches from all parts of the country have attended the meetings, and there has been an average attendance of twenty-two.

The respective branches have the following members attached:—

	Members.	Associate Members.	Associates.	Total.
Birmingham	48 (56)	81 (85)	14 (14)	143 (155)
East Midlands	32 (31)	54 (46)	8 (7)	85 (85)
Lancashire	105 (99)	197 (174)	9 (6)	311 (279)
London	75 (80)	68 (64)	12 (11)	155 (155)
Newcastle	80 (84)	86 (100)	76 (67)	242 (251)
Scottish	54 (65)	114 (150)	26 (21)	194 (240)
Sheffield	85 (86)	88 (89)	12 (12)	185 (187)
West Riding of Yorks.	34 (36)	50 (46)	— —	84 (82)
Wales and Monmouth	19 (16)	12 (11)	— —	31 (27)
General	47 (31)	44 (4)	4	95 (25)
	579 (604)	785 (810)	161 (142)	1525 (1556)

The figures in brackets are for the Session, 1923-1924.

The total number of members on the roll of the Institute on April 30, 1925, was 1,525. As the Coventry Branch has been disbanded for the present, members belonging to that Branch have been transferred to the general list. The Council regret to have to report that eight deaths have taken place during the year.

The members would learn with regret of the death in August last of Mr. Buchanan, who was the first President of this Institute in 1904 and 1905. Mr. Buchanan was also a trustee, and took a very keen interest in everything appertaining to the welfare of the Institute.

The Institute has also lost a valued member in the death of Mr. E. H. Broughall. It will be remembered that Mr. Broughall was junior Vice-President last year, but had to resign owing to ill-health.

Mr. Oliver Stubbs, a Past-President of the Institute, has been elected an Hon. Life Member in recognition of his valuable services.

Annual Conference, 1925.

This will be held on June 10, 11 and 12 in the Lecture Hall of the Institution of Engineers and Shipbuilders in Scotland, Elmbank Crescent, Glasgow, by the kind permission of the authorities.

"Oliver Stubbs" Gold Medal.

The third medal was awarded to Mr. John Shaw, of the Sheffield Branch, for his work in connection with the Test Bars Committee and meritorious services rendered to the Institute over a period of many years.

MR. V. C. FAULKNER (Senior Vice-President).

Mr. V. C. Faulkner, who was trained at Sheffield University, has specialised in electric steel manufacture. He joined the Institute in 1908, and was elected President of the London Branch in 1923.

General Council.

The members who retire in accordance with the rules are:—Messrs. W. T. Evans, A. Firth, J. Haigh, E. Carey Hill and J. G. Robinson. Messrs. Evans, Firth, Haigh and Robinson offer themselves for re-election.

Standardisation of Test Bars.

Good progress has been made during the year, and a working arrangement has been arrived at between your Committee and the B.C.I.R.A. Three joint meetings have been held and the general outline of the I.B.F. Specification accepted. From further tests it is probable the loads specified on the transverse bars will be lowered to come into line with the usual 28 cwts. now specified on the 2 in. × 1 in. + 36 in. bar. Two full meetings have also been held with the B.E.S.A., Dr. Moore, of the War Office, being elected chairman. All the great public departments and chief technical societies were represented at those meetings. Five other members of the I.B.F. were co-opted to serve on this Committee in their capacity as makers of heavy castings. While good and favourable progress has been made, no general statement can be made, as the proceedings are confidential.

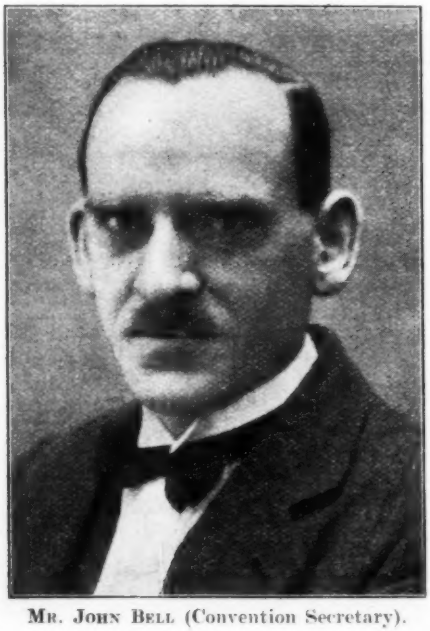
No further progress has been made with the International Bar. The home question must be settled first.

Diplomas.

These have been awarded to the following for Papers read at meetings:—E. M. Currie, Coventry; F. W. Rowe, for Paper read before East Midlands Branch; J. A. Gardner, Scottish; A. L. Key, Lancashire; A. Sutcliffe, Burnley; J. W. Gardom, London; A. Rhydderch, for Paper read before London Branch; J. F. Kayser, Sheffield; J. D. Nicholson, Newcastle; C. Gresty, Newcastle; H. B. Beeny, Coventry; O. Smalley, Newcastle; E. Longden, Birmingham; S. G. Smith, Lancashire; A. R. Bartlett, London.

British Cast Iron Research Association.

The Cast Iron Research Association during the past year has made considerable progress. After three years' office as President, Lord Weir, in accordance with the Articles of Association, resigned, and was succeeded by Sir John Dewrance, K.B.E. A distinguished group of gentlemen in the ironfounding and engineering industries accepted the office of Vice-President.



Mr. John Bell (Convention Secretary).

Mr. John Bell, the Convention Secretary, began his industrial life as an apprentice patternmaker with Messrs. Sir Wm. Arrol & Company, Limited, Dalmarnock Iron Works, Glasgow. After working some time at his trade he entered the drawing office of Messrs. Robert MacLaren & Company, Limited, Eglinton Foundry, Glasgow, and was soon appointed Chief Plant Draughtsman. A few years later he was promoted to the position of Works Manager, and while in this position was responsible for the laying down and organisation of a large brass melting and stamping plant, capable of handling 300 tons of stampings per week, as well as the usual foundry work then carried on by the firm. He also acted in conjunction with the management of Messrs. Macfarlane, Strang & Company, Limited, Lochburn Iron Works, Glasgow, in the laying down of a large extension plant at Maryhill.

In 1919 he was sent out to the United States by his firm to investigate the developments of foundry plant, particularly with reference to centrifugal castings and ingot moulds, and after his return he laid out a new department for dealing with the latter type of castings.

Mr. Bell left Eglinton Foundries at the beginning of 1921, and is now the sole partner in the firm of Albert Smith & Company, foundry engineers, this business having been taken over by him after the death of the late Mr. A. A. Smith.

The number of members has increased, and for the first time during this, the fourth year of the Association's existence, the minimum income stipulated by the Department of Scientific and Industrial Research has been reached. It has, in fact, been exceeded by a good margin, and it is hoped during the next financial year, the final year of the five-year period during which Government support was promised, to increase this margin to cover the whole of the shortage of income during the first three years.

During the year laboratories have been acquired where investigations and chemical, mechanical and microscopical tests are being conducted. In addition, important fundamental investigations are being carried out on a practical scale in foundries, and other researches are in progress at the Universities of Birmingham, Sheffield and Manchester, together with the National Physical Laboratory.

A number of research reports have been issued, and a considerable amount of material is available for early distribution. The Bulletin has been issued regularly each quarter.

The relations between the Association and the Institute have become exceedingly close. The delegate member appointed by the Institute to the Association, Mr. H. Field, attends Council meetings, and the Director of the Association has been invited to join the Council of the Institute. The two bodies have also co-operated with singular success in connection with work on a national specification for grey and malleable irons, now being considered by the British Engineering Standards Association. In this and in many other directions it is felt that the two bodies can work for the benefit of the industry.

Members of the Institute who would like information on the work of the Association are cordially invited to communicate with the Director, and it is hoped that every British manufacturer in the engineering and ironfounding industries will recognise the economic advantages of membership, by which, for a small annual subscription, benefits accruing from a total annual expenditure of over £7,000 can be secured.

American Foundrymen's Association.

The close association between the Institute and the American Foundrymen's Association is to be cemented next year, when an International gathering is to be held in the autumn at Detroit City. An official invitation is being extended to all members to participate. The system of the exchange of Papers has been continued this year.

Association Technique de Fonderie de France.

In the autumn of this year a joint meeting with the Belgian Foundry Association is being held in Liége, and members will be welcomed on that occasion.

R. O. Patterson, *President.*
W. G. Hollinworth, *General Secretary.*

Balance Sheet.

The accounts and balance sheet are presented herewith :—

Income and Expenditure Account, for the year ended December 31, 1924.

Expenditure.

			£ s. d.
Postages			87 13 10
Printing and stationery, including printing of proceedings			496 19 6
Council, finance and annual meeting expenses	36 15 5		
Expenses in connection with Cardiff branch meeting	8 4 9		45 0 2
Illuminated address			11 0 0
Branch expenses—			
Lancashire	89 13 2		
Birmingham	82 18 7		
Scottish	83 19 9		
Sheffield	60 18 9		
London	42 17 0		
East Midlands	19 6 6		
Newcastle	101 11 7		
Coventry	20 10 6		
West Riding of Yorkshire	15 14 6		
Wales and Monmouth	16 14 0		534 4 4
Audit fee and accountancy			9 9 0
Incidental expenses			23 9 2
Salaries—secretary and clerk			400 0 0
Rent of office			65 0 0
Depreciation of furniture			9 9 8
Diplomas and certificates			53 8 8
			£1,735 14 4
Donation Birmingham Chamber of Commerce	10 10 0		
Donation Faraday Society	10 10 0		21 0 0
			1,756 14 4
Excess of income over expenditure			277 7 7
			£2,034 1 11

(*Continued on page 530.*)

The Application of Metallography in Bronze Founding.

By FRANCIS W. ROWE, B.Sc. (Research Dept., David Brown and Sons (Huddersfield), Ltd.).

(*Continued from page* 494.)

The alpha solid solution, containing as it does only 6 or 7 per cent. tin, is comparatively soft and forms a good matrix. The remainder of the tin is present as the valuable eutectoid. If the alloy is annealed, it causes it to assume more nearly its stable structure. That is, the alpha absorbs more tin, becomes harder, and the eutectoid is lost. Figs. 14 and 14A illustrate this point.

Why anyone should want to anneal Admiralty gunmetals and bronzes is something of a mystery. If the strength of such alloys in their normal condition is not adequate and the presence of the eutectoid is not important, why not use an alloy with 5 or 6 per cent. tin and 5 or 6 per cent. zinc.

Phosphor Bronzes.

The primary object of adding phosphorus to a bronze is to ensure freedom from oxide. It should not be assumed, however, that because a bronze contains phosphorus that no oxide can be present, as is generally asserted, because such is definitely not the case. It is extremely doubtful whether phosphorus is capable of reducing tin oxide. If, however, in alloying a bronze the phosphor tin or

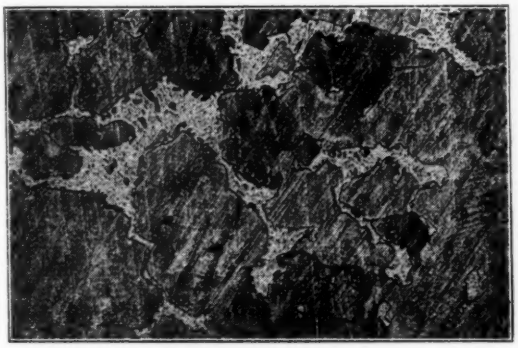


FIG. 15.—HIGH PHOSPHORUS PHOSPHOR BRONZE × 2,000 DIAS.

phosphor copper is added to the molten copper before the tin, the phosphorus combines with cuprous oxide and frees the metal from oxygen. Thus when the tin is added, there is no tin oxide formed. Cuprous oxide is present to some extent in practically all melted copper. Even electrolytic copper, unless melted under very exacting conditions, absorbs some oxygen.

A very small amount of phosphorus is sufficient to accomplish the deoxidation of copper, and if this is the sole desideratum 0.03 per cent. phosphorus will suffice. Phosphorus in excess of this amount appears in the alloy as copper phosphide Cu_3P—a comparatively hard and very brittle substance. If the alloy contains sufficient tin to have an appreciable amount of eutectoid present, this copper phosphide is not easily visible at low magnifications. It is associated with the eutectoid and with it forms a low melting point compound, melting at 620 deg. C.

One result of the addition of phosphorus is that the period of solidification of the bronze is greatly increased by the formation of this compound, and thus any liability to defects such as liquation is greatly enhanced. Fig. 15 shows the microscopical appearance of a phosphor bronze containing 1 per cent. phosphorus and 11 per cent. tin at low magnification.

Fig. 16 shows a portion of the eutectoid under a magnification of 2,000 diameters with the two constituents copper phosphide and the alpha delta eutectoid. By examining a bronze under high magnification as little as 0.04 per cent. phosphorus can be thus detected. Though it is general for the phosphide to be thus associated with the eutectoid, small patches are met with frequently structurally free. An example of this is shown in Fig. 17.

Gun Metals.

The name gun metal is now taken to refer to alloys of copper and tin which contain zinc varying from 1 to 9 or 10 per cent. Perhaps the best known is Admiralty gun metal, which is commonly interpreted to consist of 88 copper, 10 tin,

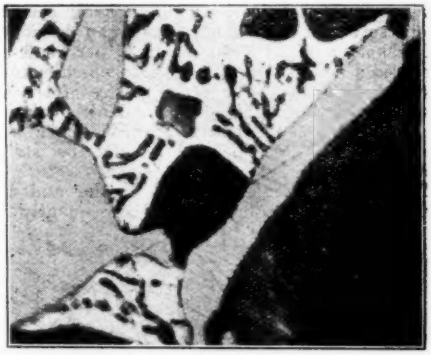


FIG. 16.—HIGH PHOSPHORUS PHOSPHOR BRONZE × 2,000 DIAS.

and 2 per cent. of zinc. The addition of zinc to a tin-bronze greatly facilitates casting operations, sound castings being obtained with less trouble, zinc being also a good deoxidant.

The zinc present is not detectable under the microscope as it is present in solution in the alpha constituent. The presence of zinc renders the alpha much harder, and for this reason gun metal is not so valuable as a plain or phosphor bronze for parts to resist abrasive wear as the difference

FIG. 17.—COPPER PHOSPHIDE IN PHOSPHOR BRONZE NOT ASSOCIATED WITH EUTECTOID × 2,000 DIAS.

in hardness between the two constituents is smaller.

The gun metals with less tin and more zinc find extensive application in industry, particularly in the manufacture of hydraulic and steam fittings. Such alloys, consisting of homogenous solid solutions, are easier to cast than the better-known Admiralty metal, as no eutectoid is present and consequently liquation and segregation troubles are non-existent. Whilst not suitable for withstanding wear, their mechanical properties are excellent.

Leaded Bronzes.

In addition to ordinary tin bronzes and phosphor bronzes for wearing duties, bronzes containing

XUM

appreciable amounts of lead (up to 12 per cent.) find extensive application for bearings. The lead appears as structurally free, metallic lead not entering into solution or combination with the other constituents. The effect of the lead is further to soften the matrix or alpha solid solution portion of the bronze and thus improve the anti-friction properties.

Naturally, it is essential to have the lead as finely divided and uniformly distributed as possible, and to this end the conditions of casting and cooling should be well studied, especially if the lead content is above 8 or 9 per cent.

The Brasses.

Metallographically, the industrial ranges of the brasses, that is from 10 to 50 per cent., are comparatively simple. Up to 35 or 37 per cent. zinc they consist wholly of a solid solution of zinc in copper known as the alpha solid solution. They show the customary dendritic cored structure unless very slowly cooled, and are all comparatively soft and very ductile and can be worked either hot or cold. After about 35 per cent. zinc is passed a new constituent appears which is known as the beta phase. The exact nature of the beta phase is not thoroughly clear, and although it is generally and conveniently regarded as a solid solution, this description may not be strictly accurate.

The beta constituent is much harder and more brittle than the alpha, and consequently the

Fig. 18.—70:30 Brass, as Cast × 200 dias.

physical properties of brasses in the cast state alter quickly when the limit of solubility of zinc in copper has been passed. After 35 or 37 per cent. zinc is passed the alloy becomes progressively richer in beta until at 48 or 49 per cent. the whole of the alloy consists of the constituent. After 49 per cent. zinc a new constituent makes its appearance which is known as gamma, the slightest traces of which render alloys unsuitable for industrial work, making them extremely fragile and brittle.

The effect of zinc on the microstructure of brasses is illustrated by the photomicrographs in Figs. 18, 19 and 20, which show respectively a 30, 40 and 43 per cent. zinc brasses. The alpha-beta brasses and the beta brasses form an extremely useful series of industrial alloys and one in which large tonnages are cast every week.

Special Brasses.

Most of the alpha-beta and beta brasses which are used for castings are those known as special or high-tensile brasses or, more incorrectly, manganese bronzes. These consist of ordinary brasses to which small amounts of special elements such as aluminium, manganese, nickel, iron or tin are added to improve the physical properties. These elements are soluble to an appreciable extent in brass, and have the effect of replacing zinc in the mixture. That is, a brass containing 65 copper, 34 zinc, and 1 per cent. aluminium would have similar metallographic structure to an alloy containing 40 zinc, 1 per cent. of aluminium being equal to 6 per cent. of zinc.

In addition to this zinc-replacing feature, the brasses containing these special elements are considerably tougher and stronger than the corresponding plain brasses, due to the refinement of grain and closer cohesion. Metallography plays an important part in the commercial production of this type of alloy, as the amounts of the alpha and the beta constituents must be carefully regulated for the duties for which the bronze is intended.

The microscope is now also extensively used for controlling the composition during melting. For heavy castings such as propeller blades, the metal is melted in reverberatory furnaces,

Fig. 19.—59:40 Brass, as Cast × 200 dias.

and, due to oxidation, it is difficult to keep the zinc contents within the necessary narrow limits without control. When the bath is nearly ready for tapping a spoon sample is taken and cast in a chill mould and a specimen rapidly cut off, polished and etched and examined to determine the relative amounts of alpha and beta. With a little practice the amount of each can be gauged to 1 or 2 per cent. equal to gauging the zinc content to 0.5 per cent. From this determination the amount of zinc required to bring the bath to the required composition is calculated. The

Fig. 20.—56:43 Brass, as Cast × 2,000 dias.

method is more accurate and reliable than the old procedure of judging the zinc contents from the fracture of chill cast spoon samples, and cannot be objected to on the score of time, as the whole operation takes only two or three minutes.

Grain Size.

One of the most profitable branches of metallography for the bronze founder is the study of grain size under different casting conditions. Much has been written regarding the best casting temperatures for different classes of alloys, but such information, whilst extremely valuable when applied under similar conditions to which it was obtained, is of very little use for the other work and other methods of moulding and running castings.

The underlying idea at the back of all pyrometric control is that the castings shall have a definite grain size known to be associated with the best physical properties for that method of casting.

Such grain size depends upon the period of time over which solidification takes place and to some extent the period of cooling after solidification. Giving equal cooling and casting conditions, the higher the casting temperature, the larger will be the grain size, and vice versa. Slow cooling after casting will also give a larger grain size than more rapid cooling, and it is of importance to appreciate these two factors in connection with grain size.

Grain size is very often visible in the machined surfaces of castings when the machining operation has been such as to produce ridges, *i.e.*, planing, shaping or rough turning. Grain size is best studied, however, at low magnifications or visually on ordinary metallographic specimens, which need not be polished with the same extreme care needed for ordinary microscopic work. Such macro-sections give one a good indication of the way the particular casting has solidified and whether the physical properties are likely to be of the best.

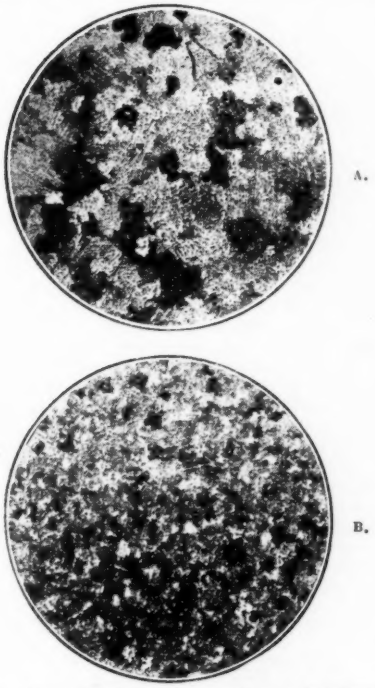


Fig. 21.—Runner End (A) and Riser End (B) of Bronze Test Bar × 2.

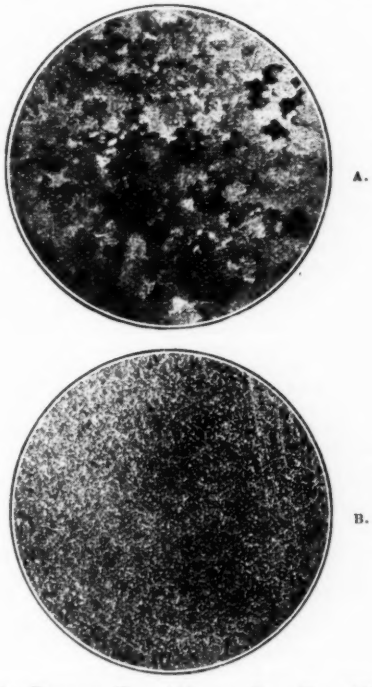


Fig. 22.—Runner End (A) and Bar End (B) of Bronze Test Bar × 2.

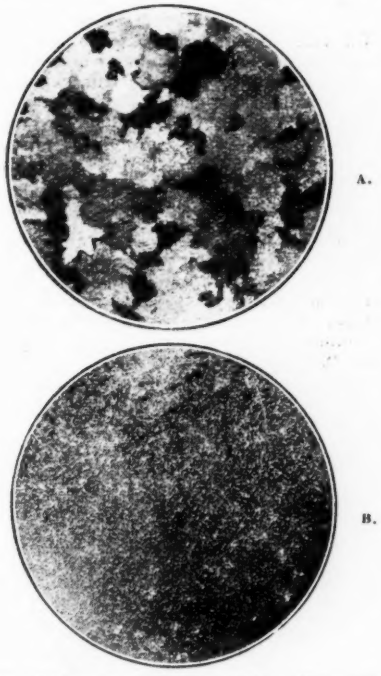


Fig. 23.—Macrosection from Near Runner (A) and Furthest Point from Runner (B) on Bronze Ring × 2.

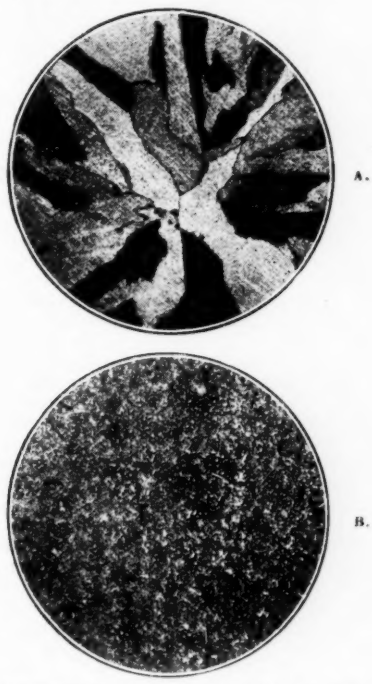


Fig. 24.—Similar Sections as 23A and B, but Higher Casting Temperature × 2.

Take, for example, the macrographs in Figs. 21 and 22. Two test bars were moulded 12 in. × 1 in. dia., and both had the same size runner, but one had a riser and the other none. The runner was 1 in. dia. all the way. Both were cast at the

same temperature—1,180 deg. C.—with bronze containing approximately 10 per cent. tin. A small section was cut from the runner and riser end of each, and the macro appearance of these are shown in Figs. 21 and 22. It is quite easy to see that the physical properties of the metal at the far end of bars will be quite different from the runner ends of the bar, particularly in the bar cast without riser. Brinell hardness tests taken on the four sections showed:—

	Load 500 *kilos.* 10 *mm. ball*
21A	63
21B	69
22A	65
22B	78

To take another example drawn from actual works practice. A large bronze ring approximately 2 ft. dia. × 4 in. × 2 in. This was cast with a down runner on one side at a predetermined temperature. The macrographs of portions taken near the runner (23A) and diametrically opposite the runner (23B) are shown.

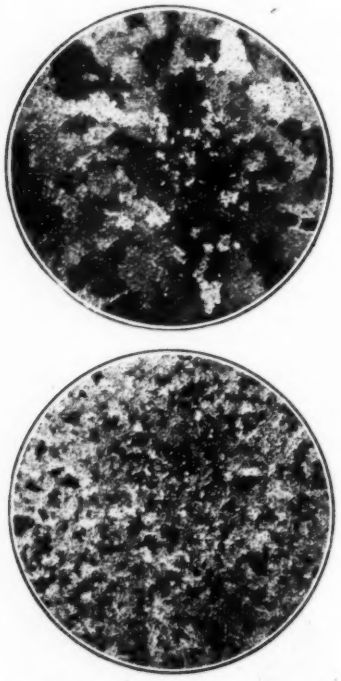


FIG. 25.—SIMILAR SECTIONS AS 23 AND 24, BUT LARGE RUNNER AND SMALL RISER.

On machining up, blowholes appeared on the opposite side of the ring to the runner. These blowholes were quite rightly attributed to cold metal. The obvious (but incorrect) cure was to raise the casting temperature. As an experiment this was done. The resulting macrographs (taken from similar portions) are shown in Figs. 24A and 24B. This time, whilst the place which formerly was blown was quite sound, the metal was open and porous near the runner, due to the metal being too hot at this section.

The correct remedy was to enlarge the runner so that the mould was filled with metal all at the same temperature or as near this ideal as possible. This is helped, in addition to enlarging the runner, by placing a small riser on the ring diametrically opposite the runner, not to act as a feeder, but so that the coldest metal shall be expelled from the mould. The resulting macrographs are shown in Figs. 25A and 25B, where the grain size both at runner side and opposite side of the casting are as uniform as is possible to obtain. These two examples will serve to indicate the necessity of watching other points beside the temperature of the metal in the ladle. Frequent defects of a similar character are often noticed in a number of castings on a pattern plate. A foundry foreman complained to the author some months ago of the extremely narrow limits of successful casting temperature for a certain type of gunmetal. His opinion was based on the following facts. He was casting a number of small valve bodies either 18 or 20 on plate in a box approximately 30 in. × 15 in. These were moulded 9 or 10 aside with a common main runner down the middle of the box gating the castings on either side. He found that at a certain casting temperature approximately 90 per cent. of the castings machined up and passed hydraulic test successfully.

If the boxes were cast at a temperature 10 deg. C. higher, nearly 50 per cent. of the castings were porous, and if cast 10 deg. C. lower, similar high percentages of scrap were experienced.

The author knew that the particular alloy should not be so susceptible in the question of casting temperature and that the casting temperature being used was well on the high side. An investigation of grain size revealed the cause of the narrow limits for casting temperature for this particular job.

The gating was such that the castings near the runner had a much larger grain size than those at the far end of the plate. What was happening was that by the time the castings at the far end of the plate were cast up, the metal had fallen so much in temperature that, unless the metal was poured at a very high temperature (right on the top limit for safety), the castings at the far end of the plate were defective. If this already very high casting temperature was increased by even so small an amount as 10 deg. C., the castings near the runner were defective. By altering the position and size of the runner so that the castings were run all at approximately the same temperature, a much greater latitude was obtained in casting temperature. Another minor application of macrographic specimens is illustrated in Fig. 26. The author had occasion to examine a large bronze casting supplied under specification with test bars cast on the casting.

FIG. 26.—MACROGRAPH (FULL SIZE) RUNNER TO TEST BAR OF LARGE BRONZE CASTING.

The casting was received with the test bars cast on. These, when pulled, gave exceptionally good results. A slight discrepancy in the analyses of turnings from the casting and turning from the test bars of the order of 0.2 per cent. in the lead content caused an investigation to be made. The runner connecting the test bar to the casting was sectioned and polished and the macrograph obtained. The cause of the discrepancy in the analyses and the exceptionally good results from the test bars was revealed. The hole on the left-hand side of the piece was one where drillings were taken prior to suspicions being aroused. The evidence of the macrograph is obviously uncontrovertible.

Whilst, perhaps, much of this Paper is platitudinous, the author trusts the importance of the points upon which he has touched are sufficient excuse for their reiteration, and that the practical men of the bronze founding industry (to whom this Paper is addressed) will find some points of interest to themselves and that it will prove some slight incentive to study further the fascinating subject of metallography and confirm or otherwise the personal opinions of the author.

In conclusion, the author would like to express his sincere thanks to the directors of Messrs. David Brown & Sons, Limited, for permission to publish this Paper and, in particular, to their managing director, Mr. Percy Brown, for his kindly interest and stimulating encouragement in all matters pertaining to the application of science to the betterment of industrial products.

Low-Temperature Heat Treatment of Special Cast Irons.*

By J. W. DONALDSON, B.Sc., A.I.C. (Associate Member).

Cast iron used in the manufacture of certain castings, such as internal-combustion engine parts, especially cylinders, cylinder covers, pistons and piston rings, is subjected to temperature conditions which have a marked effect on the properties of the metal. Of recent years ironfounders, engineers, and metallurgists, have been confronted with this problem of suitable material, and many valuable and interesting contributions have been made on this subject. A series of Papers[4] were presented to the Scottish Branch of this Institute in November of last year, and these, with the subsequent discussion, describe very fully the position regarding oil-engine castings.

Low-temperature heat treatment of cast iron has been investigated by Hurst[1], Campion and Donaldson[2], Schuz[3], and Smalley[4], and is so well known to foundrymen that it is unnecessary to do more than refer to their work here. The effect of the additions of special elements to cast iron in order to improve its qualities has also been investigated, and the data so obtained is to be found in papers by Hatfield[5], Campion[6], Smalley[7], and Piwowarsky[10].

Some two years ago, the author commenced a series of experiments combining the effects of low-temperature heat treatment and the addition of special elements on cast iron. Part of the work dealing with the effect of manganese, chromium and nickel has already been published under the title of "Some Experiments on Cast Iron."[9] The present Paper includes that work and also extends the experiments to cover the effects of tungsten and vanadium, and the combined effect of chromium and nickel on cast iron.

The composition of the various irons, together with their tensile strengths as cast, are shown in Table I. The plain iron was selected as one which is generally recognised as a good cylinder iron and one which has given good results in service. This iron, together with the manganese, chromium, nickel and vanadium irons, were prepared from the same cupola-melted metal by remelting in crucibles and casting into dry-sand moulds, 14 in. by 1⅛ in. dia. The special elements were added in the form of ferro-alloys. In the case of the tungsten iron, difficulty was experienced in adding the ferro-tungsten, and in order to get an iron containing tungsten it was found necessary to vary the composition of the original iron by altering the silicon and manganese contents. The bars, however, were also cast from cupola metal remelted in crucibles. The two nickel-chrome irons were cast directly from the cupola without remelting, the nickel and chromium being added by the addition of Mayari pig-iron to the charge. This method of manufacture accounts for the higher total carbon and the variation of the other constituents. All the irons were cast at approximately the same temperature.

* Paper read before the Glasgow Conference of the Institute of British Foundrymen.

Heat-treatment experiments were carried out under the following three sections:—(1) Prolonged annealing tests at 450 deg. C. and 550 deg. C. respectively; (2) elevated temperature tests as cast and after prolonged annealing; and (3) growth tests. The method of experimenting and the results obtained from each test are considered separately.

Annealing Tests.

Annealing experiments were carried out in two series of tests. In the first series, five bars of each iron were heated in an electric resistance furnace to a temperature of 450 deg. C. for 8 hours, allowed to cool overnight, then reheated the following day for the same period. At the end of every five days, corresponding to 40 hours' heating, a bar was removed and its composition as regards total and combined carbon determined, together with its tensile strength and Brinell hardness. The results are given in Tables II and III.

In the second series of tests, a similar procedure was followed, excepting that the bars were heated to 550 deg. C. instead of 450 deg. C. The results obtained are given in Tables IV and V.

TABLE I.—*Chemical Analyses and Tensile Strengths.*

Mark.	P.	M.	C.	N.	V.	W.	C.N.1	C.N.2
	%	%	%	%	%	%	%	%
Graphitic carbon ..	2.48	2.55	2.24	2.50	2.49	2.24	2.54	2.55
Combined carbon ..	0.68	0.77	0.93	0.67	0.70	0.78	0.76	0.78
Total carbon	3.16	3.32	3.17	3.16	3.19	3.02	3.30	3.33
Silicon	1.48	1.52	1.40	1.56	1.45	1.89	1.89	1.21
Sulphur	0.054	0.014	0.04	0.095	0.084	0.064	0.06	0.09
Phosphorus	0.704	0.706	0.686	0.673	0.693	0.679	0.212	0.17
Manganese	0.97	2.43	0.973	0.943	0.994	0.764	0.71	0.64
Chromium	—	—	0.392	—	—	—	0.495	0.607
Nickel	—	—	—	0.746	—	—	0.245	0.300
Vanadium	—	—	—	—	0.124	—	0.013	0.020
Tungsten	—	—	—	—	—	0.475	—	—
Tensile strength, Tons per sq. in.	16.6	17.6	18.4	16.8	17.0	17.6	15.9	17.8

TABLE II.—*Annealing Tests at 450 deg. C.*

Cast iron.	Duration of heating in hours	T.C.	C.C.	Tensile strength	Brinell hardness.
				Tons.	
P.	0	3.16	0.68	16.6	223
	40	3.17	0.64	16.2	212
	80	3.17	0.48	15.7	197
	120	3.19	0.43	15.3	183
	160	3.13	0.38	15.4	183
	200	3.15	0.38	15.5	179
				Tons.	
M.	0	3.32	0.77	17.6	223
	40	3.29	0.74	—	217
	80	3.31	0.73	16.8	197
	120	3.35	0.55	16.5	183
	160	3.28	0.56	—	183
	200	3.33	0.54	16.4	183
				Tons.	
C.	0	3.17	0.93	18.4	248
	40	3.18	0.90	17.9	235
	80	3.17	0.85	17.5	212
	120	3.18	0.72	17.4	207
	160	3.16	0.69	17.2	201
	200	3.20	0.69	17.3	207
				Tons.	
N.	0	3.16	0.67	16.8	223
	40	3.18	0.18	16.0	167
	80	3.18	0.09	14.8	159
	120	3.16	0.08	14.8	159
	160	3.17	0.07	14.7	156
	200	3.15	0.07	14.7	149

Consideration of the results obtained in those tests show that prolonged annealing at 450 deg. C. and 550 deg. C. respectively produces changes in the various irons. In each case the combined carbon is decomposed, the tensile strength falls off, and the Brinell hardness decreases. The degree of change varies for the different irons and is more marked at 550 deg. C. than at 450 deg. C. In Table VI a summary of the results is given, showing the number of hours required to produce more or less stable conditions,

TABLE III.—*Annealing Tests at 450 deg. C.*

Cast iron.	Duration of heating in hours	T.C.	C.C.	Tensile strength	Brinell hardness.
				Tons.	
V.	0	3.19	0.70	17.0	235
	40	3.20	0.18	16.5	174
	80	3.21	0.09	14.9	159
	120	3.22	0.09	14.6	159
	160	3.20	0.08	14.9	159
	200	3.23	0.07	15.0	152
				Tons.	
W.	0	3.02	0.78	17.6	212
	40	3.04	0.72	17.1	192
	80	3.07	0.63	16.8	183
	120	3.03	0.59	16.5	179
	160	3.07	0.60	16.5	183
	200	3.05	0.60	16.5	179
				Tons.	
C.N.1	0	3.30	0.76	15.9	229
	40	3.23	0.68	15.6	223
	80	3.25	0.60	15.1	217
	120	3.23	0.56	14.9	207
	160	3.25	0.58	14.8	197
	200	3.26	0.57	14.9	197
				Tons.	
C.N. 2	0	3.33	0.78	17.8	255
	40	3.28	0.70	17.5	235
	80	3.27	0.64	17.2	217
	120	3.27	0.59	16.8	207
	160	3.27	0.60	16.8	201
	200	3.32	0.58	16.7	201

TABLE IV.—*Annealing Tests at 550 deg. C.*

Cast Iron.	Duration of heating in hours	T.C.	C.C.	Tensile strength	Brinell hardness.
				Tons.	
P.	0	3.16	0.68	16.6	223
	40	3.13	0.12	15.8	138
	80	3.16	0.11	15.1	129
	120	3.15	0.09	14.8	129
	160	3.15	0.12	14.6	125
	200	3.14	0.12	14.8	129
				Tons.	
M.	0	3.32	0.77	17.6	223
	40	3.36	0.69	16.4	187
	80	3.30	0.46	16.1	171
	120	3.35	0.27	15.4	159
	160	3.35	0.25	15.2	148
	200	3.34	0.26	15.4	148
				Tons.	
C.	0	3.17	0.93	18.4	248
	40	3.16	0.57	17.9	207
	80	3.22	0.53	17.4	171
	120	3.20	0.49	16.8	159
	160	3.15	0.51	16.4	148
	200	3.21	0.49	16.4	148
				Tons.	
N.	0	3.16	0.67	16.8	223
	40	3.19	0.15	16.3	163
	80	3.20	0.05	13.8	138
	120	3.14	0.05	13.4	134
	160	3.20	0.04	12.9	129
	200	3.15	0.02	13.4	129

and the percentage decrease in the combined carbon, tensile strength, and Brinell hardness when these conditions are attained.

On heating the plain cylinder iron at 450 deg. C. the carbide is decomposed to the extent of 34 per cent. This change requires 160 hours' heating to complete, and is accompanied by a decrease in the tensile strength of 7 per cent. and in the Brinell hardness of 18 per cent. Heating to 550 deg. C. produces a carbide change of 82 per cent after 40 hours' heating, the tensile strength falling off by 11 per cent. and the Brinell hardness by 42 per cent.

Influence of Manganese.

Increasing the percentage of manganese in the iron from 0.97 per cent. to 2.43 per cent. increases the stability of the combined carbon probably due to the formation of manganese carbide, which crystallises with the iron carbide, forming a double and more stable carbide. This is indicated by a smaller decrease per cent. in the combined carbon both at 450 deg. C. and 550 deg. C.

Influence of Chromium.

The addition of a small amount of chromium 0.392 per cent. produces a similar but more powerful effect than the 1.5 per cent. increase in manganese. The initial tensile strength is increased considerably and also the percentage of combined carbon. This carbide, due to the presence of chromium carbide, is more stable under temperature, showing less tendency to decompose. The tensile strength and Brinell hardness shows smaller

TABLE V.—*Annealing Tests at 550 deg. C.*

Cast iron.	Duration of heating in hours	T.C.	C.C.	Tensile strength	Brinell hardness.
				Tons.	
V.	0	3.19	0.70	17.0	235
	40	3.14	0.18	14.8	170
	80	3.19	0.08	13.0	134
	120	3.22	0.06	12.0	129
	160	3.14	0.05	12.0	134
	200	3.23	0.03	11.8	129
				Tons.	
W.	0	3.02	0.78	17.6	212
	40	3.02	0.72	17.1	192
	80	3.00	0.52	16.2	179
	120	3.03	0.34	15.8	159
	160	3.01	0.28	14.9	143
	200	3.01	0.27	15.0	143
				Tons.	
C.N. 1	0	3.30	0.76	15.9	229
	40	3.28	0.67	15.1	207
	80	3.28	0.52	14.7	187
	120	3.27	0.43	14.0	—
	160	3.22	0.36	13.9	159
	200	3.28	0.37	13.8	159
				Tons.	
C.N. 2	0	3.33	0.78	17.8	255
	40	3.31	0.68	17.2	223
	80	3.31	0.56	16.6	187
	120	3.33	0.42	16.1	163
	160	3.33	0.40	15.8	167
	200	3.33	0.40	15.9	163

percentage decreases at 450 deg. C. At 550 deg. C. the decreases are somewhat similar to those obtained with the plain cylinder iron, but when the initial tensile strength is considered it is seen that even after stable conditions are attained by annealing the chromium iron at 550 deg. C., the final tensile strength is similar to that obtained in the cylinder iron as cast.

Influence of Nickel, Vanadium, and Tungsten.

Nickel added to cast iron to the extent of 0.746 per cent. produces little effect in the cast condition, but has a marked effect when the iron is heated. At 450 deg. C. it produces rapid decomposition of the combined carbon to the extent of 87 per cent., and at the higher temperature of 550 deg. C. decomposition is almost complete. This carbide change is accompanied by a large decrease in the strength and hardness.

A small percentage of vanadium 0.124 per cent. produces changes very similar to those produced by the larger percentage of nickel. The decrease in tensile strength after annealing at 550 deg. C. is most marked.

Annealing at 450 deg. C. the iron containing 0.475 per cent. of tungsten produces changes somewhat similar to those produced in treating the chromium iron at a similar temperature. Raising the annealing temperature to 550 deg. C.,

however, affects the stability of the carbide in this iron, and produces more rapid decomposition than is produced in the chromium iron under similar conditions. The changes at this temperature are somewhat similar to those produced in the manganese iron when similarly treated.

Influence of Nickel-Chromium.

The two chrome-nickel irons, owing to the difference in their carbon, silicon, and phosphorus contents, are scarcely comparable with the other irons.

TABLE VI.—*Percentages Changes Produced by Annealing.*

Cast iron.	450 deg. C.				550 deg. C.			
	Duration of heating in hours.	Combined carbon, decrease per cent.	Tensile strength, decrease per cent.	Brinell hardness, decrease per cent.	Duration of heating in hours.	Combined carbon, decrease per cent.	Tensile strength, decrease per cent.	Brinell hardness, decrease per cent.
P.	160	34.0	7.0	18.0	40	82.0	11.0	42.0
M.	120	27.0	6.0	18.0	120	67.0	12.0	33.0
C.	120	25.0	5.5	16.0	120	46.0	11.0	31.0
N.	80	87.0	12.0	30.0	80	94.0	18.0	40.0
V.	80	88.0	12.0	32.0	80	94.0	29.0	45.0
W.	120	23.0	5.7	15.5	160	65.0	14.7	33.0
C.N.1 ..	120	25.0	6.3	14.0	160	51.0	13.0	31.0
C.N.2 ..	120	26.0	6.2	21.0	120	49.0	10.6	36.0

The principal difference between those two irons is the lower silicon content and higher chromium and nickel contents of the second. This difference in composition has a noticeable effect on the initial strengths and hardness of the irons, but little effect on their heat-resisting properties as the percentage decreases are somewhat similar. The second iron, however, even after prolonged annealing at 550 deg. C., has a strength superior to the first iron in its cast condition. The general effect of annealing on the two irons produces conditions somewhat similar to those produced on the straight chromium iron by similar treatment.

TABLE VII.—*Elevated Temperature Tests.*

Cast iron.	Breaking temperature degs. C.	As cast.	Annealed for 200 hrs. at 450° C.	Annealed for 200 hrs. at 550° C.
	Degs.	Tons.	Tons.	Tons.
	15	16.6	15.5	14.8
	100	16.1	14.9	13.8
	200	15.8	14.5	13.6
P.	250	15.2	—	—
	300	14.9	13.8	12.4
	350	15.7	—	—
	400	16.5	13.0	11.0
	500	15.1	12.2	10.4
	600	11.7	7.6	4.8
	Degs.	Tons.	Tons.	Tons.
	15	18.4	17.3	16.4
	100	18.0	17.1	16.2
C.	200	17.8	17.1	15.8
	300	17.8	17.2	15.6
	400	17.8	17.1	15.2
	500	17.8	16.0	15.2
	600	12.8	11.0	9.4
	Degs.	Tons.	Tons.	Tons.
	15	17.6	16.5	15.0
	100	17.8	16.6	15.0
	200	16.6	16.0	14.9
W.	250	16.2	—	—
	300	16.1	15.7	15.0
	350	16.6	—	—
	400	17.0	14.7	14.2
	500	15.0	14.2	12.0
	600	10.2	9.3	7.1
	Degs.	Tons.	Tons.	Tons.
	15	17.8	16.7	15.9
	100	17.0	16.6	15.6
C.N.2	200	17.4	16.1	15.0
	300	17.8	15.9	14.5
	400	18.0	15.2	13.8
	500	15.0	12.2	10.6
	600	8.6	7.5	6.4

Consideration of Results.

Consideration of the various results indicates that low-temperature annealing decomposes the carbide with a corresponding decrease in the strength and hardness of the iron. The addition of small amounts of special elements has in the case of chromium, tungsten and manganese a stabilising effect on the carbide; whereas in the case of nickel and vanadium the decomposition of the carbide is accelerated. A small percentage of chromium, about 0.4 per cent., produces the best results. It might be noted here that this percentage of chromium is the maximum amount that can be added to an iron of the composition experimented with, larger amounts producing irons so hard that difficulty is experienced in machining them. Tungsten to the amount of 0.5 per cent. and manganese to the amount of 2.5 per cent. affect iron in a somewhat similar manner, but while increasing the stability of the carbide over that of the plain iron do not produce the same degree of stability as the smaller amount of chromium does. In iron containing both chromium and nickel, chromium exerts the predominating effect, the nickel allowing of the introduction of a larger percentage of chromium than would be possible if chromium were added alone. A similar result would no doubt be obtained by increasing the silicon content in the straight chromium iron.

Elevated Temperature Tests.

Elevated temperature tests were carried out on the plain cylinder iron and on the special irons showing the best results from the annealing tests, namely, the chromium, tungsten, and second chrome-nickel irons. Sufficient bars were not available to carry out tests with the manganese iron.

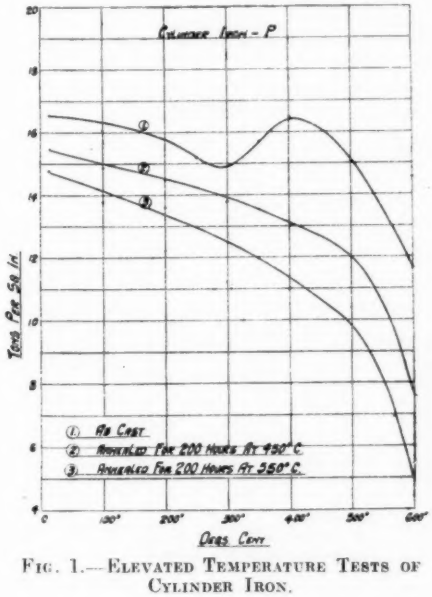


FIG. 1.—ELEVATED TEMPERATURE TESTS OF CYLINDER IRON.

In carrying out those tests a set of bars from each of the irons was broken at temperatures ranging from atmospheric to 600 deg. C. A second set from each iron was annealed for 200 hours at 450 deg. C. and then broken over the same temperature range, while a third set was annealed for 200 hours at 550 deg. C. before breaking. In carrying out the tests the bars were heated in an electric-resistance furnace attached to the testing machine, the tem-

perature being measured by thermo-couples fixed to the top and bottom of the bars. Each bar was maintained for half an hour at the temperature determined on before breaking. The results obtained from the various tests are given in Table VII and Figs. I to IV.

Consideration of the results in general indicate that if either of the irons are to be submitted to temperatures ranging from 450 to 550 deg. C. tests obtained in their cast condition cannot be taken as

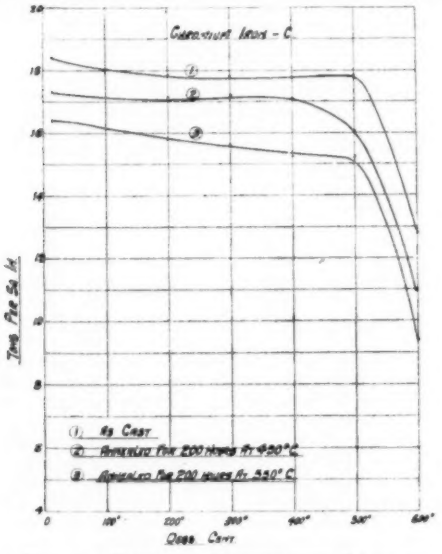


FIG. 2.—ELEVATED TEMPERATURE TESTS OF CHROME IRON.

representative. In the cast condition the tendency is for the strength of iron to diminish slightly as the temperature rises and then to increase again with a further rise in temperature, attaining a maximum in the neighbourhood of 400 deg. C., after which the strength rapidly diminishes with increasing temperature. In the case of the chromium iron and to a lesser extent in the case of the chrome-nickel iron, the curves obtained are more regular, and in the chromium iron the

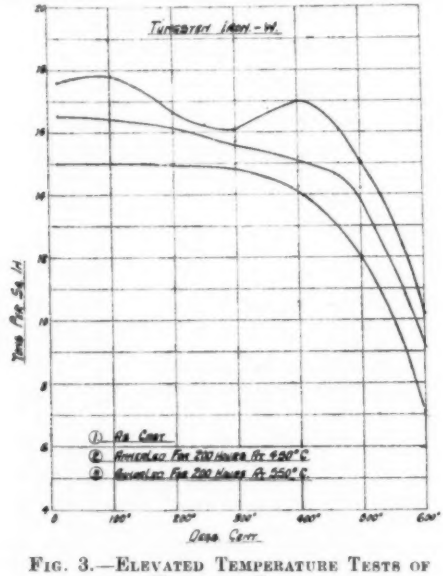


FIG. 3.—ELEVATED TEMPERATURE TESTS OF TUNGSTEN IRON.

strength is maintained to 500 deg. C. before falling off.

Subjecting the irons to prolonged annealing at 450 and 550 deg. C. produces, as previously indicated, changes in their composition, with the result that when the irons are tested at elevated temperatures a considerable diminution in strength takes place. The curves obtained in each case are more regular, the strength diminishing uniformly as the temperature increases. The decrease in strength is fairly large, showing in the case of the cylinder iron when tested at 400 deg. C. decreases of 21 per cent. and 27 per cent, after annealing at 450 and 550 deg. C. respectively, and in the case of the chromium iron decreases of 4 per cent. and 15 per cent. after similar annealings and when tested at the same temperature. The decreases in the tungsten and chrome-nickel iron under similar conditions are intermediate between those figures.

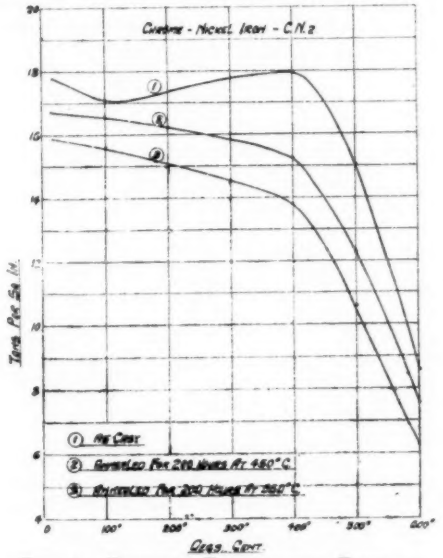


FIG. 4.—ELEVATED TEMPERATURE TESTS OF CR-NI IRON.

The curves obtained on breaking each iron at temperatures from atmospheric to 600 deg. C. after prolonged annealing at 450 and 550 deg. C. respectively are given in Figs. V and VI. Testing at 400 deg. C. after a 450 deg. C. annealing the relative increases in tensile strength for the chromium, tungsten, and chrome-nickel irons, over the ordinary cylinder iron, are 32 per cent., 13 per cent., and 17 per cent. After a 550 deg. C. annealing the corresponding increases are 38 per

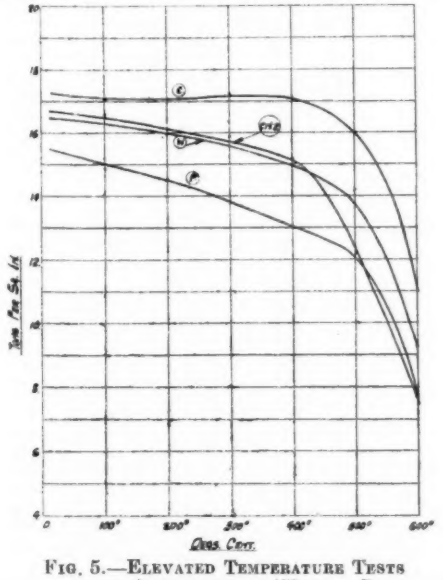


FIG. 5.—ELEVATED TEMPERATURE TESTS AFTER ANNEALING AT 450 DEG. C.

cent., 30 per cent., and 25.5 per cent. At both temperatures the stability and superiority of the iron containing chromium is marked.

Growth Tests.

These tests were carried out on all the irons at a temperature of 550 deg. C. Two bars from each iron, accurately machined to 6 in. in length and 1 in. in diameter, were heated in an electric resistance furnace daily for a period of 8 hours,

allowed to cool overnight, and reheated the following day. After five heatings the bars were removed and accurately measured by means of a Whitworth measuring machine reading to hundred thousandths of an inch. The average measurements obtained, together with the volumes calculated from them and the changes per cent., are given in Tables VIII and IX. A graphic representation of the results is given in Fig. VII.

The amount of growth which takes place in each of the irons is small when compared with the growth of an ordinary foundry iron. This is shown in Fig. IX, where the results obtained from

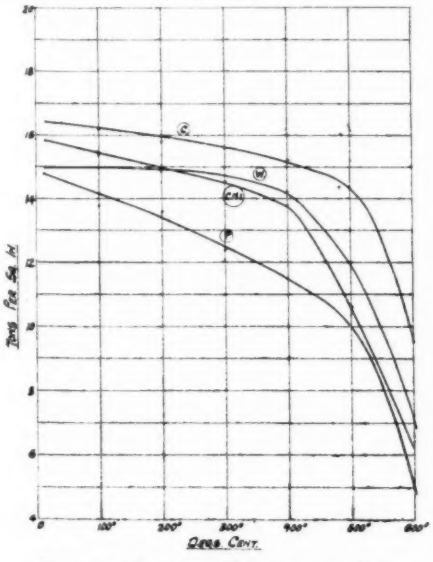


FIG. 6.—ELEVATED TEMPERATURE TESTS AFTER ANNEALING AT 550 DEG. C.

the different irons are given along with the results obtained from a foundry iron of the following composition: Total carbon, 3.29; graphitic carbon, 2.72; combined carbon, 0.57; silicon, 1.75; sulphur, 0.11; phosphorus, 1.54; and manganese, 0.16 per cent.

Growth in the cylinder iron attains a maximum after 10 heatings, when the volume increases by 0.13 per cent. The manganese and vanadium irons give curves similar to each other, the most growth taking place during the first 10 heatings and then slowly to 25 heatings with a slight ten-

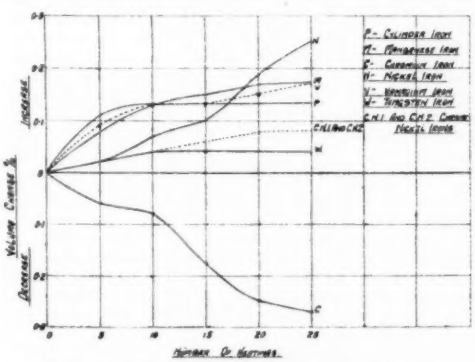


FIG. 7.—GROWTH TESTS AT 550 DEG. C.

dency to rise; change of volume after 25 heatings amounting to 0.17 per cent. Growth in the nickel iron takes place slowly at first, but increases with the number of heatings yielding a volume change of 0.25 per cent. after 25 heatings and still increasing. There is little change with the tungsten iron, a maximum change of 0.04 per cent. being obtained after 10 heatings. With chromium there is contraction instead of growth. This contraction takes place slowly for 10 heatings, then more rapidly to 20 heatings, then slowly again to 25 heatings where the volume has decreased by 0.27 per cent. The two chrome-nickel irons do not show contraction, although they both contain a higher chromium content, the effect of chromium in producing contraction evidently being prevented by the presence of the nickel. Both irons show little growth, attaining a maximum of 0.08 per cent. after 20 heatings.

Summary and Conclusions.

The conclusions derived from the various tests may be summarised and stated as follows:—

(1) Annealing cast iron for prolonged periods at temperatures of 450 deg. C. and 550 deg. C. respectively, produces changes in the composition of the iron which affect the strength and hardness of the material. These changes are due to decom-

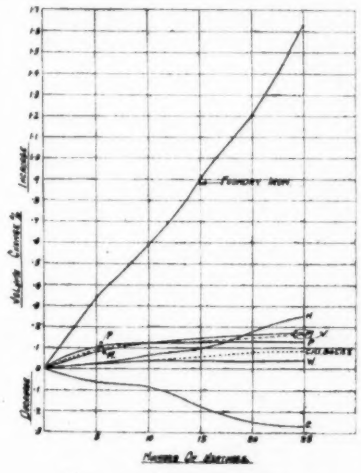


FIG. 8.—GROWTH TESTS AT 550 DEG. C.

position of the carbide, and are more marked at the higher temperature.

(2) If cast iron is to be subjected to elevated temperatures, its strength at those temperatures cannot be determined on cast bars. The material has to be annealed at the working temperature until the carbide change is complete before making tests.

(3) Cast iron, if of suitable composition, will show very little growth or change of volume after repeated heatings and coolings.

TABLE VIII.—*Growth Tests at 550° C.*

Cast iron	Number of heatings.	Length, ins.	Diameter, ins.	Volume, cub. ins.	Change per cent.
P.	0	6.0000	1.0000	4.710	0
	5	6.0004	1.0005	4.715	0.11
	10	6.0011	1.0006	4.716	0.13
	15	6.0010	1.0006	4.716	0.13
	20	6.0011	1.0006	4.716	0.13
	25	6.0011	1.0006	4.716	0.13
M.	0	6.0000	1.0000	4.710	0
	5	6.0004	1.0004	4.714	0.09
	10	6.0007	1.0006	4.716	0.13
	15	6.0009	1.0007	4.717	0.15
	20	6.0011	1.0007	4.718	0.17
	25	6.0010	1.0007	4.718	0.17
C.	0	6.0000	1.0000	4.710	0
	5	5.9992	0.9998	4.707	0.06
	10	5.9985	0.9997	4.706	0.08
	15	5.9979	0.9992	4.701	0.18
	20	5.9980	0.9989	4.698	0.25
	25	5.9978	0.9988	4.697	0.27
N.	0	6.0000	1.0000	4.710	0
	5	6.0004	1.0001	4.711	0.02
	10	6.0010	1.0003	4.713	0.07
	15	6.0025	1.0004	4.715	0.10
	20	6.0030	1.0008	4.719	0.19
	25	6.0035	1.0010	4.722	0.25

(4) Small additions of special elements modify the properties of cast iron, both as regards annealing and strength at elevated temperatures as well as the growth properties.

(5) The addition of chromium to the extent of 0.4 per cent. modifies the properties of the iron to the greatest extent. The initial strength is increased by 11 per cent., the carbide is rendered more stable on annealing, with a corresponding

smaller reduction in the strength and hardness; and the breaking strength at 400 deg. C. after stability is attained with prolonged annealing is 25 per cent. greater than that obtained with a corresponding iron containing no chromium. Repeated heatings and coolings to 550 deg. C. produce a small decrease in volume instead of growth.

(6) Increasing the manganese from 1.0 per cent. to 2.5 per cent., or adding 0.5 per cent. of tungsten produces results somewhat similar to each other and similar to those produced by the chromium but by no means so marked. The growth of both irons is small, that of the tungsten being practically nil.

(7) Adding 0.75 per cent. of nickel or 0.125 per cent. of vanadium slightly improves the initial

TABLE IX.—*Growth Tests at 550° C.*

Cast Iron	Number of heatings.	Length, ins.	Diameter, ins.	Volume, cub. ins.	Change per cent.
V.	0	6.0000	1.0000	4.710	0
	5	6.0015	1.0003	4.714	0.09
	10	6.0019	1.0005	4.716	0.13
	15	6.0020	1.0005	4.716	0.13
	20	6.0020	1.0006	4.717	0.15
	25	6.0021	1.0007	4.718	0.17
W.	0	6.0000	1.0000	4.710	0
	5	6.0002	1.0001	4.711	0.02
	10	6.0005	1.0001	4.712	0.04
	15	6.0008	1.0001	4.712	0.04
	20	6.0007	1.0001	4.712	0.04
	25	6.0008	1.0000	4.712	0.04
C.N.1	0	6.0000	1.0000	4.710	0
	5	6.0003	1.0001	4.711	0.02
	10	6.0007	1.0002	4.712	0.04
	15	6.0010	1.0003	4.713	0.06
	20	6.0010	1.0004	4.714	0.08
	25	6.0011	1.0004	4.714	0.08
C.N.2	0	6.0000	1.0000	4.710	0
	5	6.0004	1.0002	4.712	0.04
	10	6.0006	1.0002	4.712	0.04
	15	6.0008	1.0002	4.713	0.06
	20	6.0010	1.0002	4.714	0.08
	25	6.0010	1.0002	4.714	0.08

strength of iron, but renders the carbide less stable during annealing, a large amount of graphitisation taking place even at 450 deg. C. with a corresponding large decrease in the strength and hardness.

(8) The effect of adding both chromium and nickel in the proportion of 2 and 1 allows the use of a higher percentage of chromium, although it would appear that the benefits derived from the increased chromium as regards stability of the carbide and strength at elevated temperatures are more than diminished by the accompanying nickel. Better results would no doubt be obtained by omitting the nickel and increasing the chromium with additional silicon.

For permission to publish these tests, the author's thanks are due to Mr. James Brown, C.B.E., and the other directors of Messrs. Scotts' Shipbuilding & Engineering Company, Limited, Greenock.

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[2] Campion and Donaldson, "Proceedings of Institution of British Foundrymen," 1921-22. Vol. 15, pages 211-231.
[3] Schuz, "Stahl u. Eisen," 1922. Vol. 42, pages 1484-88.
[4] Smalley, "Proceedings of Institution of British Foundrymen," 1921-22. Vol. 15, pages 588-714.
[5] Hatfield, "Cast Iron in the Light of Recent Research," Chap. 6.
[6] Campion, FOUNDRY TRADE JOURNAL, September, 1918, Vol. 20, pages 467-470.
[7] Smalley, "Proceedings of Institution of British Foundrymen," 1922-23. Vol. 15, pages 495-535.
[8] Symposium, FOUNDRY TRADE JOURNAL, Vol. 30, page 475.
[9] Donaldson, "Journal of West of Scotland Iron and Steel Institute," Vol. 31, pages 54-62.
[10] Piwowarsky, FOUNDRY TRADE JOURNAL, Vol. 31, pages 331-334, 345-346.

ALFRED HERBERT, LIMITED, have terminated their agreement with the J. M. Carpenter Tap & Die Company, Pawtucket, R.I., U.S.A., and have entered into an agreement with the Morse Twist Drill & Machine Company. They will, in future, be agents for all Morse carbon steel tools, and sole agents in Great Britain and Ireland for all Morse screwing tackle. Large stocks of these tools will be carried at Coventry and elsewhere.

Trade Talk.

JOHN DAVIS & SON (DERBY), LIMITED, All Saints' Works, Derby, have completed extensions to their works.

THE CORONIUM METAL COMPANY, LIMITED, Brentford, Foundry, Brentford, Middlesex, have removed to Reading.

J. F. CROWLEY & PARTNERS have removed from 16, Victoria Street, Westminster, S.W.1, to 11, Queen Anne's Gate, Westminster, S.W.1.

THE INTERNATIONAL ELECTRIC COMPANY, LIMITED, have new offices at 161a/166, Strand, London, W.C.2, but the works remain at Tottenham as hitherto.

A FIRE OCCURRED in an engineering workshop at the premises of Bardsley & Company, Fitzwilliam Lane, Sheffield, recently, but little damage was done.

IT IS POSSIBLE that the mining of manganese ore in the hills of the Lecht, in the Banffshire parish of Kirkmichael, which intervene between Donside and Avenside, may be revived. The extent of the deposits is now being ascertained on behalf of a North of England concern. Iron ore was first worked in the neighbourhood in 1736.

OPERATIONS in connection with the salvage of the twelfth German destroyer at Scapa Flow were commenced by Cox & Danks, Limited, at the beginning of the month. On June 6 the destroyer was successfully raised. It is understood that another German floating dock has been acquired by Cox & Danks, Limited. It is one of the largest floating docks in the world, and part of it is expected to be used next spring in the salvage of the cruisers "Hindenburg" and "Seydlitz." Fourteen destroyers have yet to be raised.

IMPORTANT ORDERS have just been placed by the London Midland and Scottish Railway Company for the supply of steel rails. These are apportioned as follows: Steel, Peech & Tozer, Limited, 10,000 tons; Cammell, Laird & Company, Limited, 10,000 tons; Samuel Fox & Company, Limited, Stocksbridge, 10,000 tons; the Workington Iron & Steel Company, Limited, 10,000 tons. Further large orders for steel rails have been placed by the same company in Scotland, with the Shelton Iron, Steel & Coal Company, Limited, and with firms on the East and West Coasts (United Steel Companies, 20,000 tons), and in South Wales.

THOS. W. WARD, LIMITED, of Sheffield, have acquired the ironworks of Eastwood, Swingler & Company, Limited, of Derby, for the purpose of being dismantled. The business was taken over by the receivers in April last. The firm of Eastwood, Swingler & Company, Limited, was one of the oldest in Derby, having been founded about 1850, and had a capital of £100,000. The concern was badly hit by the slump in trade, and the workshops, once so flourishing and active, have now come to a standstill. It will be remembered that since the closing of the works Miss Eastwood, granddaughter of the founder, has promised to meet all deficiencies, which amount to many thousand pounds.

THE REPORT of the Chemical and Metallurgical Corporation, Limited, states that in the circular dated December 13, 1924, reporting on the experimental work carried on at Stratford, it was stated that the initial difficulties of reproducing on a large scale the results obtained in smaller plant had been surmounted, and that improved methods had been devised for the treatment of various low-grade and complex ores and the conversion of the metal values into commercial products. The company's intention was originally to derive its income principally from the granting of licenses for the use of its process, but the experience gained at the Stratford works has shown the directors that in its present form the process can be employed more advantageously by the company operating its own works. While by a comparatively small expenditure the plant at Stratford may be made to earn profits by supplying a local market for certain refined lead and zinc products, the plant was not designed and is not suitable for the economical treatment of large quantities of ore which can better be dealt with at a site favourably situated for receiving shipments of ore and in the neighbourhood of facilities for the treatment of the zinc residues. The directors have given careful consideration to proposals for re-organising the company's capital with a view to the provision of funds for establishing the business on a profit-earning basis. If advantage is to be taken of the inventions now controlled by the company it will become necessary to consider the question of erecting a first commercial unit at some point on seaboard, having the advantage of cheap water freights and the advantage for shipment of the zinc residues resulting from the treatment of the ores, to zinc smelters, either in England or Belgium, none of these advantages being possessed by the Stratford works, and where, owing to limitation of space, any enlargements that may be necessary in the future could not be secured.

The Present Status of the Laboratory Investigation of Sands.

By H. RIES, Ph.D.

(*Continued from page* 498.)

Base Permeability.

This may be a new term to many, and need explanation. It has been found, for example, that a given sand with coarse grain, but appreciable clay substance, may give a relatively low-permeability when tested by itself. If now the clay substance is washed out of the sand and the dry permeability of the grain determined alone, it may be found to be considerable. This is the base permeability. As stated by Dietert in a Paper previously referred to, "The base permeability is of utmost importance, for it compares the permeability of all sands under like conditions. Some high-clay sands are dense, due to the amount of clay they contain. If natural permeability is the only thing considered, one would class these sands as closing-up sands for heap-sand, while in reality they may have a very open grain-structure, which would be shown in the base permeability reading. When the clay-content of this sand is reduced by mixing it into the heap, its open grain-structure would act as an opener. All new sand placed in a heap-sand will be brought to some predetermined clay-content by sand control. In order to determine what the various new sands will do to a heap-sand they should have their base permeability determined."

Density of Sand.

In any test where the sand has to be compacted it is recognised that a varying degree of compaction will affect the results. Thus, with a given sand and a given moisture content increased compaction will tend to increase the strength as measured by the methods referred to above, and decrease the permeability. Recognition of this has been made by the sub-committee, and the force of compaction used in the several tests is that which gives a body having the same degree of density as the average mould.

Experiments made on different sands when compacted in cylinders show that uniform compaction is not obtained from the top to bottom of the core in all cases. Thus, in the permeability tests as recommended by the A.F.A. the core of sand made with the rammer is made 2-in. high, because it gives fairly uniform compaction throughout its length. A core, say, 4-in. high, if rammed all at once, would not show uniform compaction. To overcome this difficulty as much as possible, Dietert has suggested the use of "double-end-ramming," as it is called. This is done by having a movable rammer sliding into the cylinder from below. To prevent the cylinder from sliding down over it, a hole is drilled in the rammer for a pin. This holds the cylinder in place until the sand is put in it. The upper rammer is then let down into the upper end of the cylinder, and the pin is withdrawn before the sliding weight on rod of upper rammer is dropped. As a result of this equal ramming forces are applied to both ends of the sand specimen during the ramming operation, and more uniform compaction results.

Optimum Water Content.

It is probably widely recognised by now that the permeability and bonding strength vary with the amount of moisture which the sand contains, and that the quantity of moisture which gives the maximum development for either the bonding strength or permeability is called the *optimum water content*. Therefore curves can be plotted showing the permeability and bonding strength for different percentages of moisture. In all of the sands first tested at the Cornell University sand laboratory it was noticed that the curves for both properties showed a well-developed peak within the moisture range at which the sand could be worked. As more and more sands were tested, however, it was found that there seemed to be many exceptions to this.

Fig. 6 shows the permeability and bonding strength curves of over 200 sands tested within the moisture range at which they were workable. These have been divided into three classes, of which the upper pair of curves in each case may be taken as the type:—

In Class I the peaks of the curves agree; in Class II the permeability peak P occurs at a lower moisture content than that of the bond test curve B; and in Class III the position of the peaks is reversed. It will be observed that in several cases no peak is shown, due probably to the fact that it is developed when the sand is too wet or too dry to be workable. The reason for this is evidently to be sought for in the quantity and nature of the clay substance present, and has been discussed at some length in a Paper on "The Relation of Moisture to Permeability and Bond," presented by C. M. Nevin at the October, 1924, meeting of the A.F.A.

Moisture Determination.

Since the amount of moisture in a sand exerts an important influence on the permeability and bonding strength, frequent determinations of it may be necessary. The common method for determining the moisture content is that of heating

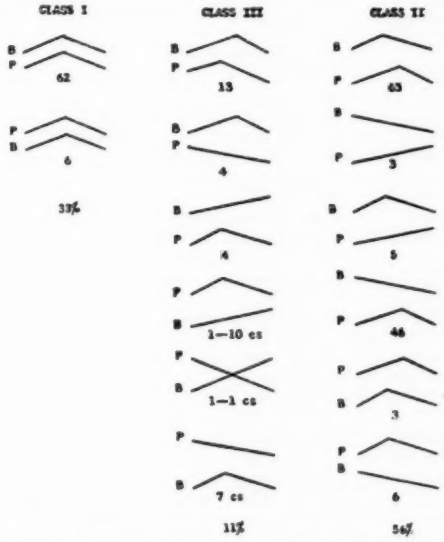


FIG. 6.—PERMEABILITY AND BOND STRENGTH CURVES OF OVER 200 SANDS TESTED FOR GEOLOGICAL SURVEY.

the sand in a hot-air bath at a temperature between 105 and 110 deg. C., and finding the loss in weight. This is a comparatively slow process, and requires at least an hour. There is need, therefore, of having a rapid method applicable to all sands.

It is interesting to note, however, that certain rapid methods have been tried with some success in foundry-control work where the same sand or sands are in daily use. F. L. Wolf and A. A. Grubb* use an apparatus consisting of four electric heating chambers arranged to pass dry air at about 400 deg. F. (205 deg. C.) through as many samples of sand contained in small aluminium capsules. There is also an automatic weighing-device equipped with a chart that indicates the percentage moisture without calculation. A single test takes from 5 to 8 minutes, and 30 to 40 determinations can be run in an hour.

H. W. Dietert† has devised another rapid

* American Foundrymen's Association, Preprint No. 430, October, 1924.

† American Foundrymen's Association, Preprint No. 425, October, 1924.

method based on the following principle:—If a tube is filled with water, and moist sand is put in it, the amount of water displaced will depend on the amount of water already contained in the sand. A definite amount of moist sand is therefore put in a water-filled cylinder. The water displaced overflows and is caught in a graduated tube, from which graduations the percentage of moisture in the sand can be read.

Refractoriness and Life.

These two terms, according to the writer's conception, do not mean the same thing. Refractoriness would seem to apply to the temperature at which a sand fuses; life refers to the length of time a sand can be used over and over without losing its important properties. There is as yet no standardised method of determining either of these properties, but studies leading to that end are under way.

There seems to be a diversity of opinion as to how a refractoriness test should be made, one group holding that the fusion point of the sand as received should be tested, while others believe that it is more important to determine the refractoriness of the bond alone. The writer is inclined to agree with the latter group, because in most sands it is the more resistant minerals, such as quartz, which compose the grain, and these are usually of high refractoriness, while the bond commonly contains fluxing impurities, which lower its fusion point.

There have not been many figures published on this point in the United States, but some interesting ones have appeared in a Paper by Rhydderch.* Aside from the fusion point of the sand, it is the opinion of many that the vitrifying point or softening point of the sand as a whole should be determined.

Longevity of Sands.

There is no doubt that other things equal, some sands deteriorate more rapidly than others, and require a larger amount of new sand to be added to the heap from time to time. One should not overlook the fact that the life of a sand will be influenced by the size of the casting made in it. Admitting that some sands burn out quicker than others, those sands which have a longer life or burn out less rapidly are the more desirable, and if this quality can be determined beforehand, it may mean a considerable saving to the foundryman.

Experiments are now under way to test out a method useful for this purpose. One suggested and used by H. W. Dietert and some others consists in heating the sand to a temperature of 600 deg. F. (315 deg. C.) for two hours, after which it is tested to determine its change in permeability and bonding strength. This test gives promise of being a reliable one. Mr. Dietert† has found that some moulding sands lost as much as 87 per cent. of their strength by the above-mentioned heat treatment, while others lost as little as 16 per cent. Curiously enough, the permeability may either increase or decrease.

Dye Absorption.

One of the supplementary tests recommended by the Sub-Committee on Tests is that of dye absorption, the object of which is to determine the nature and amount of the true clay substance in the sand or, to state it in different words, the colloidal matter. Theoretically, then, if a sand contains a high percentage of bonding substance, it should show a high dye absorption and *vice versa*. It cannot be said that there is unanimity of opinion regarding the value of this test, and, moreover, while it is true that a sand of high bonding-strength may show a high dye absorption, and *vice versa*, still it seems as if in many cases there is only a general relation between the two properties.

One may therefore be justified in seeking an explanation of this. Dye absorption is a surface phenomenon, and colloidal matter, because of the great surface area of the particles, would naturally absorb a relatively large amount of dye. But would not silica flour or fine silt also show the same property, and although it exhibits it to a less degree, one can easily realise that if a sand contained a considerable percentage of fine silt, that its dye absorption might be appreciable. Then, too, sands which have been heated to redness, a temperature sufficient to destroy all true bonding material, may still absorb some dye. So from these facts alone it may be concluded that it is not the colloidal bond only which takes up the dye.

To go still further, Holmes, in a Paper familiar to many, has called attention to the difference between mobile and static bond. According to Gramme's experiments quoted by Lemoine,* the static bond seems to give little or no strength to the sand. May this static bond not also absorb some dye?

Finally, in the dye absorption test as usually carried out, the dye used is crystal violet, which is an acid dye, and hence would be absorbed best by basic colloids. Might there not be acid colloids present which would react best towards a basic dye like safranine, for example? The concentration of the dye solution also plays an important *rôle*, and must not be overlooked. Notwithstanding these objections which have been raised against the dye test by some, it has been found useful by others who have used it satisfactorily in foundry control work. This may be due in part to its being employed for testing different lots of the same sand.

Chemical Analyses.

In looking over the literature one notices that chemical analyses of moulding sands appear to have been made more frequently in Europe than in the United States, which might lead one to believe that greater importance is attached to them in the former. The Sub-Committee on Tests has recommended a method for analysing sands which is practically the same as that ordinarily used, but a quantitative analysis is not regarded as essential in all cases.

It would no doubt be of importance in "steel" sands, and even many core sands, but for ordinary moulding sands the writer fails to see that it can perform any real service. As pointed out by him some years ago, it is not difficult to find brick clays that show a chemical composition identical with moulding sands.*

If there was a satisfactory and accurate method of making a rational analysis which was applicable to impure materials, it might give some interesting data, but such a method has not yet, so far as the author is aware, been discovered.

Mineralogy of Moulding Sands.

The writer believes that there is here an interesting field for study, which may lead to practical results. It involves, however, considerable careful petrographic work, which should be checked up with practice. Moulding sands are likely to be made up largely of the more resistant minerals, such as those which withstand the destructive effects of weathering and erosion. Of these, quartz would be the most common, but one sometimes nears the statement made that minerals of relatively low weathering resistance, like feldspar, may be present in considerable amounts. If this is really so, do they play any *rôle* in the behaviour of the foundry sands, which should be considered and may affect their commercial value? The statement is also made that mica is injurious. Is it really present in any considerable amount, and what is its effect? Lime and the alkalies are not considered desirable. If present, are they there as constituents of mineral grains or otherwise? Numerous other questions will suggest themselves, and whilst a petrographic study is being made of the sand grains, their form should also be considered to determine what effect this has on the properties of the sand. There is, then, in the microscopic study of sands a large and interesting problem.

Dry Sand Testing.

No reference has been made in the preceding matter as to whether the tests discussed are for

* Foundry Trade Journal, May 29, 1924.

† American Foundrymen's Association, Preprint No. 425, October, 1924.

* M. R. P. Lemoine, L'Etat Actuel de la Question des Sables de Moulage, 4me Congrès de Fonderie, Paris, November, 1924.

* Ries, H., "The Relative Advantages of the Physical and Chemical Examinations of Moulding Sands," Metal Industry (New York), 1908.

green sand or dry sand, although their applicability may be inferred. The bar test and tensile strength test strength are assumedly for green sands. The compression test can be made on either green or baked sands. The same holds true of the permeability test. Baked cores are sometimes tested by fastening them in the end of the cylindrical sand container, making a paraffin connection and coating the sides of the core with paraffin. This permits air to be forced through the full length of the core. Baked cores are sometimes submitted to a cross-breaking test, and two of the compression machines now being tried are adapted for testing bars by cross-breaking.

SUMMARY.

Before closing this brief review the writer desires to emphasise again if possible the practical value and broadness of application of some of the tests which have been suggested. Tests like those for strength, permeability, fineness, life and refractoriness are, any or all, of importance.

(1) They may be applied to new sands for the purpose of determining how they compare in their properties with those already in use.

(2) They may be used by the sand producer to check his consignments and determine whether they are running uniform.

(3) The foundryman can use these tests to check new consignments which he is receiving from the quarry, so that if they do not agree with satisfactory sands from the same quarry previously received, he can reject the truck load. This is actually done.

(4) Last, but by no means least, the foundryman can use these methods for daily foundry control, employing them equally for sand mixtures as for individual sands. He may find that if his heap maintains a certain moisture content, permeability and strength, all goes well, but that if there is too much deviation from certain figures, the losses at once become noticeable.

A most interesting and concise statement of the application of testing methods to foundry control was given by H. W. Dietert* at the Milwaukee meeting of the A.F.A. in October. Mr. Dietert states that in order to determine the value of sands for their particular work, all samples submitted are tested for permeability, strength, clay-substance, texture, base permeability, lime and longevity. Truck load consignments must check within 20 per cent. of values obtained from samples submitted. For control work in the foundry the properties determined are permeability, strength and moisture, with an occasional sieve test.

Further evidence regarding the value of control work is given by Wolf and Grubb in another Paper presented at the same meeting.† These two Papers present printed testimony, which has been confirmed by many others verbally, in some cases accompanied by a statement of the actual money saving which has been accomplished by their use.

It is felt that the establishment of what it is hoped may be regarded as standard methods of testing is a step in the right direction; in fact, the author is sure that it is, but there are still more steps to be taken, and the forward movement from one to the next will have to be made cautiously, and sometimes only after considerable research has been done.

It has been pleasing to hear the comments of approval of at least some of the tests made by friends across the water, but they should remember that all tests recommended by the committee are presented tentatively, and allowed to stand for a year for any criticism that anyone wishes to make. And so Americans welcome constructive comments not only from the foundrymen of their own country, but of those from other countries.

NALDER BROTHERS & THOMPSON, LIMITED, Lane Works, 97A, Dalston Lane, E.8, have added a new bay to their instrument shop.

HENRY WIGGIN & COMPANY, LIMITED, have established a London branch at Victoria Station House, S.W.1, which will be in charge of Mr. L. Robinson, their London agent.

* American Foundrymen's Association, Preprint No. 425, October, 1924.

† American Foundrymen's Association, Preprint No. 430, October, 1924.

Cast-Iron Research.

The council of the British Cast Iron Research Association has recently extended the research programme by arranging for an investigation on the influence of silicon, manganese and phosphorus on the formation of graphite in cast iron, to be conducted by Mr. M. L. Becker, at the University of Manchester, under the supervision of Professor F. C. Thompson, and for an investigation to be commenced at the National Physical Laboratory, under the supervision of Dr. W. Rosenhain, on the alloy systems iron-silicon, iron-manganese, iron-phosphorus in the presence of carbon over the range usually associated with cast iron. It is anticipated that these funramental investigations will yield information of great value in connection with other investigations in hand.

At a recent meeting of members it was decided that the maximum annual subscription should be reduced to 100 guineas per annum. The minimum is at present 5 guineas per annum for the smallest foundries, and varies with the size of the foundry concerned.

New Members.

Recent new members of the Association include Henry Wallwork & Company (1920), Limited, Manchester; Boulton & Paul, Limited, Norwich; British Piston Ring Company, Limited, Coventry; A. S. Smith & Sons, Walsall; Castings, Limited, Walsall; John Fowler (Don Foundry), Limited, Sheffield; Linotype & Machinery, Limited, Altrincham; Metropolitan-Vickers Electrical Company, Limited, Manchester; C. & B. Smith, Wolverhampton; J. Stone & Company, Limited, London; Charles W. Taylor & Son, Limited, South Shields; John Wood & Sons, Limited, Wigan; The Midland Electric Manufacturing Company, Limited, Birmingham; Edward Stevenson, Limited, Nottingham; Centrifugal Castings, Limited, Kilmarnock; Ransomes, Sims & Jefferies, Limited, Ipswich; R. E. Barker, Purston; the Goldendale Iron Company, Limited, Tunstall; British Engine, Boiler and Electrical Insurance Company, Limited, Manchester; National Boiler & General Insurance Company, Limited, Manchester; the Worsley Mesnes Ironworks, Limited, Wigan; and the Staveley Coal & Iron Company, Limited.

The director and consultant of the Association are now visiting Continental laboratories and works for the purpose of examining recent foundry developments, particularly in Germany.

Gazette.

A WINDING-UP ORDER has been made against the Warwickshire Bridge and Engineering Company, Limited, 36, Parade, Leamington.

THE PARTNERSHIP heretofore subsisting between Messrs. P. J. Macdonald Poupard and C. S. Cadel, iron, steel and metal merchants and agents, 39, Victoria Street, S.W.1, under the style of Poupard & Cadel, has been dissolved. The agency department of such business will be carried on in the future by Mr. P. J. Macdonald Poupard, at 139, Cannon Street, London, E.C.4. The merchant department of the business will be carried on by Mr. C. S. Cadel, under the style of C. S. Cadel & Company, at 39, Victoria Street, S.W.1.

A MEETING of the creditors of the firm of Blair & Company, Limited, has been held at Stockton. The liquidator (Sir Gilbert Garnsey) said that details of assets and liabilities was a matter of deep regret that the company had been unable to weather the storm. The longer work was carried on the more the assets were diminishing. If anything were to be saved liquidation had had to be ordered at once. The principal item of liability was £210,000 in respect of Excess Profits Duty, Corporation Profits Tax, and Income Tax, which, however, might be reduced to not more than £30,000. The principal assets were works, plant, etc., which might realise over £200,000. There were ordinary unsecured trade creditors for goods supplied amounting to about £6,200. There were preferential creditors for wages, rates, etc., accrued, amounting to £4,700. Turning to the assets side, there were sundry debtors estimated to produce £6,700, stocks and work in progress should produce at least £20,000, whilst there were sundry cash balances of £3,500, making a total of more readily realisable assets of over £30,000. There was one further matter he had to refer to, and that was that included amongst the assets of the company was an item shown to be as a deposit with the Gould Steamships and Industrials, Limited, amounting to over £400,000. This was unsecured, and would realise nothing.

THE NORTH BRITISH DIESEL ENGINE WORKS, LIMITED, have decided to arrange for the temporary closing of their works.

Malleable Iron.

By F. H. HURREN, A.I.C., M.I.Brit.F.

(*Continued from page 502.*)

Cost of Special Boxes.

Annealing pans add considerably to the cost of production. The effective life of an annealing pan varies from three to eight heats, and it will be found that the consumption is about 12 cwts. of annealing pans per ton of castings annealed. Many different types of annealing pans have been put on the market, but personal experience has been that with most of these patented types the weight of the pan is increased without a corresponding improvement of its effective life. The use of a high-chromium iron in pan manufacture reduces enormously the loss by scaling, but the cost is prohibitive. The price of this material is in the region of 3s. 9d. per lb., and as in the Rover Foundry the average stock of pans in use exceeds 90 tons weight, one can readily see that this item alone would entail an outlay of over £30,000.

Lines for Future Research Indicated.

From the foregoing it will be apparent that the manufacture of malleable iron castings is not a simple matter, to be lightly undertaken. In conclusion, it would seem desirable to indicate what appears to be the lines on which research is most necessary, and which would, to the greatest degree, assist the malleable founder in the problems with which he is so often confronted.

(1) The most urgent investigation is one on the production of pig-iron specially for the malleable trade. It has always appeared that the manufacturers of pig-iron look on the malleable founder as an outlet for iron which is unsuitable for steel making, and do not make a pig specially suited to the needs of the trade. In consequence, no two deliveries of iron even approximate to the same composition. It should be reasonable to expect from the blast furnace a pig-iron of guaranteed composition, with a medium-low total carbon, silicon within a specified range, and specified maximum sulphur, phosphorus, and manganese contents. This is possible in ordinary grey iron practice, and the Rover Company have purchased hundreds of tons of grey iron under such conditions. Why should it not be possible for the hematite pig-iron suppliers to supply to analysis? In the author's opinion it is a commercial proposition. If the foundry could be supplied with iron which only varied within known limits, many of the troubles associated with malleable iron would be eliminated, and the foundry would have definite data on which to base their annealing practice. This is a matter of vital importance to the malleable trade, and unfortunately the pig-iron suppliers will go on in the old haphazard way until the trade as a whole insist on better treatment, and pressure can be brought to bear by united action.

(2) An exhaustive research into the effect of varying percentages of total carbon and silicon and their influence on annealing. What is the maximum and minimum carbon content desirable in the hard casting?

(3) A determination of the exact temperature range during which annealing takes place, and the effect of time on the ultimate results.

(4) Determination of the maximum total carbon content desirable in the annealed casting, and the proportions in which this should be split up between the free and combined states. Personal experience has shown that in sections up to, say, ¾ in. thick, to obtain the greatest toughness and ductility, the total carbon content should not be more than 1.8 per cent., and divided approximately equally as free and combined.

(5) Full investigation as to the respective merits of continuous and intermittent firing; and in the latter case, what is effected by periods of reduction of temperature, for what length of time should these periods extend, and through what range of temperature should they occur?

(6) A full research into the physical chemistry of annealing. Definite information is required as to the changes which occur, at what temperatures they occur, how long the changes continue, and in what manner rate of cooling modifies the result. In connection with this subject it is desirable to know the reason why in some instances carbon is eliminated whilst in others it is merely transformed in state.

(7) Is elimination of carbon caused by oxidation, and in what form must the carbon be retained to effect the maximum elimination?

(8) The conditions arising which cause carbon to be deposited as finely divided graphite, and how these conditions may be avoided.

(9) The effect of composition of packing medium on the annealing process.

(10) The influence of mass on the changes which occur during annealing.

(11) Whether casting temperature has any influence on the changes which take place during annealing, due to differences in grain size? It is reasonable to assume that both casting temperature and rate of cooling of the hard casting will cause modifications in grain size, and may, or may not, affect the ultimate result.

(12) The influence of subsequent work on annealed castings, such as brazing, or reheating for "setting"; and in what manner any deleterious effect can be avoided.

These do not embrace the whole of the researches urgently needed, but the solution of these problems would go far to help the malleable founder produce a reliable article, and rehabilitate malleable iron in the eyes of engineers and designers. Who will undertake this research? Will it be left to private enterprise, or have the British Cast Iron Research Association the power, ability and financial resources, together with the moral courage necessary for such a stupendous task?

If malleable founders would only realise that unity is strength, and pool their resources for their common weal, the author is convinced the results achieved would justify any means.

Personal.

MR. S. NICHOLS, for many years on the staff of the Birmingham office of the British Thomson-Houston Company, Limited, has been appointed manager of the company's office at Middlesbrough.

MR. A. H. BESCHE, until recently sales director of Kerr, Stuart & Company, Limited, has been appointed general sales manager of the engineering department of James & Frederick Howard, Limited, of Bedford.

MR. T. FENDER, a special director of Vickers, Limited, whose retirement, on medical advice, from the active service of the company was recently announced, was born at Newcastle-on-Tyne 61 years ago. Educated at the Elswick Works School and Institute in that city, he served his apprenticeship with Sir W. G. Armstrong, Whitworth & Company, Limited, at their Elswick Works, and, after filling a staff position as foreman in the gun department, was in due course appointed to the machine inspection department. In 1901 Mr. Fender left Elswick and joined the staff of Vickers, Limited, at Barrow-in-Furness, with the object of introducing the premium bonus system of payment by results, an achievement which he successfully accomplished, though not without encountering considerable opposition. In 1910 Mr. Fender was appointed works superintendent at Barrow, and in 1919 he was made a special director of the company, a position which he will retain for a further period of two years, in order that the board may have the benefit of his expert advice.

Wills.

WALKER, W. N., of Walsall, director of Walker Bros., Limited	£4,769
MACARTHUR, A., of Auburn House, Clifton Down, Bristol, iron merchant, late of Macarthur & Company	£89,734
HOOD, D. W., engineer-in-chief to the Corporation of Trinity House, formerly with D. & C. Stevenson, of Edinburgh	£5,116
BLAKEBOROUGH, F. B., for a long period connected with J. Blakeborough & Sons, Woodhouse Brass and Iron Works, Brighouse	£17,708

Aluminium-Alloy Castings.*

By S. L. ARCHBUTT, F.I.C. (National Physical Laboratory).

It is characteristic of solid solutions to be tough and ductile, and of intermetallic compounds to be hard and brittle. According to the properties desired in castings the metallurgist must choose, therefore, as far as possible the metals he adds with a view to their behaviour on solidification of the alloy. As far as research has progressed up to the present, comparatively few metals which can usefully be added have been found to possess any considerable solubility in solid aluminium. A notable exception is zinc. Under conditions of equilibrium, zinc dissolves to the extent of approximately 18 per cent. Under similar conditions aluminium will hold approximately 3 per cent. of copper. In castings, however, less than 3 per cent. of copper is sufficient to cause the separation of crystals of a compound of copper and aluminium. With other common metals, *e.g.*, manganese, iron, nickel, the solubility is still less, and still smaller additions cause the separation of hard compounds of the added metal from the solidifying melt.

Another fact restricting the number of other metals which can usefully be added to aluminium is the readiness with which this metal forms definite compounds. Compounds are formed, or appear to be formed, with copper, nickel, manganese, iron, magnesium, to mention common metals only.

The presence of these compounds in the free state in the solid alloy is very effective in producing hardening, but at serious expense in ductility. Moreover, increase in hardness is not necessarily accompanied by increased tenacity. This is illustrated by the binary copper-aluminium alloys, where in both sand and chill castings increase of copper beyond 4 per cent. produces no notable increase in the tenacity at ordinary temperature, but does increase hardness, as, for example:

Copper per cent. ...	4.5	7	8	12
Hardness (Brinell) ...	47	57	60	82

The addition of other metals of low solubility in solid aluminium and which form compounds has a similar general effect.

In view of the above facts, it is not surprising to find that the metals principally called upon to effect the toughening of aluminium in alloys in industrial use to-day are zinc and copper.

Zinc-Aluminium Alloys.

Zinc is one of the cheapest and most satisfactory hardeners for aluminium. Zinc-aluminium alloys are, however, exceptionally weak at high temperature, leading to ready cracking in moulds under contraction stresses. Replacement of part of the zinc by copper has resulted in the development of one of the most serviceable casting alloys we have for general engineering purposes—"L5" alloy—containing zinc 12.5 to 14.5 and copper 2.5 to 3 per cent., stable in all climates and hardening appreciably with age. This alloy can, moreover, be drop forged. Recent investigations† indicate that although in resistance to atmospheric and sea water corrosion it is inferior to certain other alloys, it is not so bad in this respect as it has been painted.

Copper-Aluminium Alloys.

Binary alloys of copper with aluminium containing 8 to 12 per cent. copper have proved eminently suitable, particularly for production of castings in metal moulds. They are superior to the zinc alloys in strength at high temperatures, and the alloys containing 8 and 12 per cent. copper, L11 and L8 respectively, have been, and still are, extensively employed for pistons, cylinder-heads, etc., of internal-combustion engines.

Addition of small quantities of tin and/or zinc to this type of alloy with a view to improving casting qualities, *e.g.*, fluidity, are of doubtful wisdom, both these metals having a detrimental effect on strength at high temperatures. On the other hand, addition of manganese (1 per cent.) has been shown materially to improve strength at high temperatures.

The "Y"-Alloy.

Employing copper-aluminium as a base, more complex alloys have been developed containing in addition nickel and magnesium and iron and magnesium which possess properties very much superior to those of the plain copper-aluminium alloys, particularly at high temperatures. An alloy of the first-mentioned type known as "Y"-alloy, containing copper 4, nickel 2, magnesium 1.5 per cent., remainder aluminium, has a strength/weight ratio in the untreated cast condition at ordinary temperature considerably superior to that of many other alloys in common use, *e.g.*, L5, L8, L11.

Although of comparatively recent development, this alloy has been very thoroughly tried out in practice and, coupled with its strength at high temperatures, resistance to corrosion and amenability to heat treatment, has established itself as one of the most valuable casting alloys available.

Duralumin and Alpax.

There is one other element more properly classed with the non-metals than the metals, the presence of which in small quantities in all commercial aluminium led to the early development of that remarkable wrought alloy, Duralumin, and the addition of which to aluminium in larger quantities has more recently resulted in development of a valuable casting alloy, that is, silicon. Aluminium and silicon form a simple eutectiferous series, the eutectic containing 10.5 per cent. silicon. In the solid state aluminium will hold in solution at ordinary temperature approximately only half as much silicon as copper, namely, 1.5 per cent. No aluminium-rich compound is, however, formed,

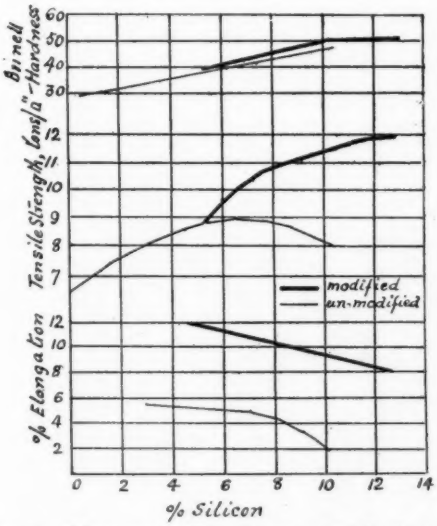


FIG. 1.—MECHANICAL PROPERTIES OF AL-SI ALLOYS.

and the excess silicon is deposited from the solidifying melt in the form of needles and plates of silicon. A valuable Paper dealing with those alloys was presented by Basch and Sayre‡ to the American Foundrymen's Association last year (1924). The variation of tensile properties and hardness of sand-cast test bars with silicon content is shown in Fig. 1. Up to 5 to 6 per cent. addition of silicon produces a comparatively rapid increase in tenacity without, however, so marked a decrease in ductility or increase in hardness as occurs, for example, with copper, so that with 5 per cent. there is available an alloy which, sand-cast, has a tensile strength of the order of 8 tons per sq. in.

* Paper read before the Glasgow Conference of the Institute of British Foundrymen.

† "Resistance of Various Aluminium Alloys to Salt-water Corrosion," Basch and Sayre, "Mechanical Engineering," Vol. 46, 1924.

‡ "Foundry Treatment and Physical Properties of Silicon-Aluminium Sand Castings."

with elongation of 5 per cent. on 2 in. From 5 to 8 per cent. silicon, little further accession of strength is obtained in the sand-cast alloy. At this point, however, the remarkable modification process discovered in 1920 by Aladar Pacz, of Cleveland, Ohio, consisting of treatment of the molten alloy with certain fluxes, comes to the rescue whereby the otherwise coarse structure of the high-silicon alloys is rendered fine with great benefit to physical properties. Normal and modified structures are shown in Figs. 2 and 3.

The optimum silicon content for the modified alloy appears to be round about 13 per cent., giving in the sand-cast condition tensile strength

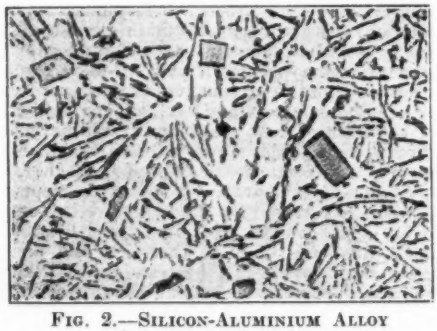


Fig. 2.—Silicon-Aluminium Alloy Unmodified × 150 dias.

of the order of 12 tons with elongation as high as 8 per cent. on a 2-in. gauge length.

This alloy combines high tensile strength and ductility with remarkable casting properties (fluidity, etc.), general soundness and toughness at high temperatures, in a manner at present unapproached by other cast-aluminium alloys. In considering the utility of the alloy for highly stressed parts, however, it must be borne in mind that although under shock or repetition stresses its ability to resist actual fracture is high (Basch and Sayre's results indicate that the safe range of stress in fatigue may be as much as 50 per cent. higher than that of L8, L11 or L5 alloys), a comparatively low elastic limit coupled with high ductility leads to distortion, which may readily become objectionable in amount at stresses considerably below those required for actual fracture.

The silicon-aluminium alloys are lighter than aluminium itself, and considering tensile strength alone, the strength/weight ratio of the modified 13 per cent. alloy is high, much superior to that of the plain copper-aluminium alloys L8 and L11, and equal, if not superior, to that of "Y" alloy

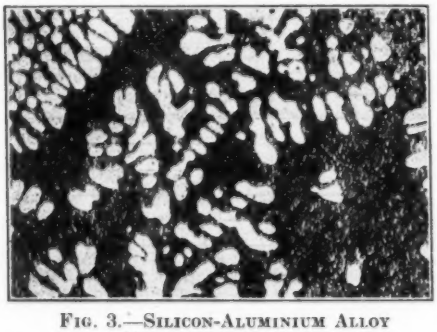


Fig. 3.—Silicon-Aluminium Alloy Modified × 150 dias.
(This and Figs. 2, 15 and 16 are from Rosenhain and Archbutt's Paper on Light Aluminium Alloys to the E. M. and M. Congress.)

in the unheat-treated condition. Taking elastic limit, however, as the measure of strength, the alloy appears to be no better than the 8 per cent. copper alloy, and is, of course, much inferior to an alloy such as "Y" in the heat-treated condition.

The alloys above mentioned—L5, L8, L11, Si/Al and "Y"—have all been very thoroughly tried out, and are satisfactory and dependable if chosen with due regard to the purpose for which they are required, *e.g.*, for high temperatures. For pistons, cylinder heads, etc., L5 should not be employed, but copper-aluminium (L8, L11), or, better still, "Y"-alloy. So far as actual breaking stress goes, the 13 per cent. silicon alloy, although superior to L8 or L11 at lower temperatures up to about 200 deg. C., appears to be no better than these alloys at higher temperatures, and is inferior to "Y."

For highly stressed castings advantage should be taken of the superior elastic limit and fatigue resistance of heat-treated "Y" alloy wherever possible. L5 alloy can be and is satisfactorily used, however, where stresses are not unduly severe and temperatures are normal, *e.g.*, for many

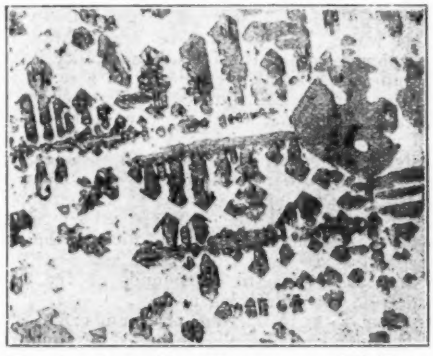


Fig. 4.—Chill Cast Unetched × 150 Dias.
(From J. Inst. Met., 1921, 26, Plate 26.)

engine crank cases, gear boxes, rear axle casings, etc.

Specifications for L5, L8, L11 and "Y" alloy have been issued by the British Engineering Standards Association.

Heat Treatment.

Considerable attention has been devoted in recent years to the question of improvement of strength of aluminium alloys by heat treatment. Great improvement is possible and has been demonstrated in the case of a number of alloys. The remarkable phenomenon of spontaneous hardening or age-hardening as it is now termed, undergone by certain types of aluminium alloys after quenching from suitable temperatures, was discovered by Wilm about 20 years ago, and as a result the well-known proprietary alloy duralumin was developed.

Wilm's discovery was made on worked material and for many years it was believed that age-hardening was not applicable to cast alloy.

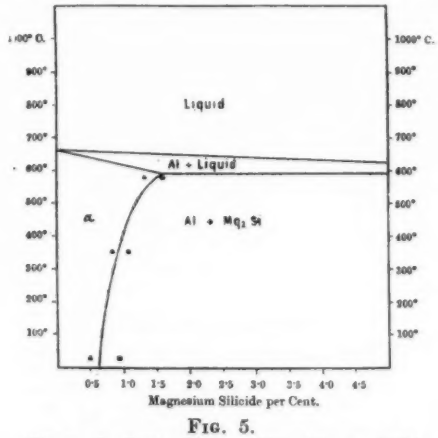


Fig. 5.
(From J. Inst. Met., 1921, 26, p. 342.)

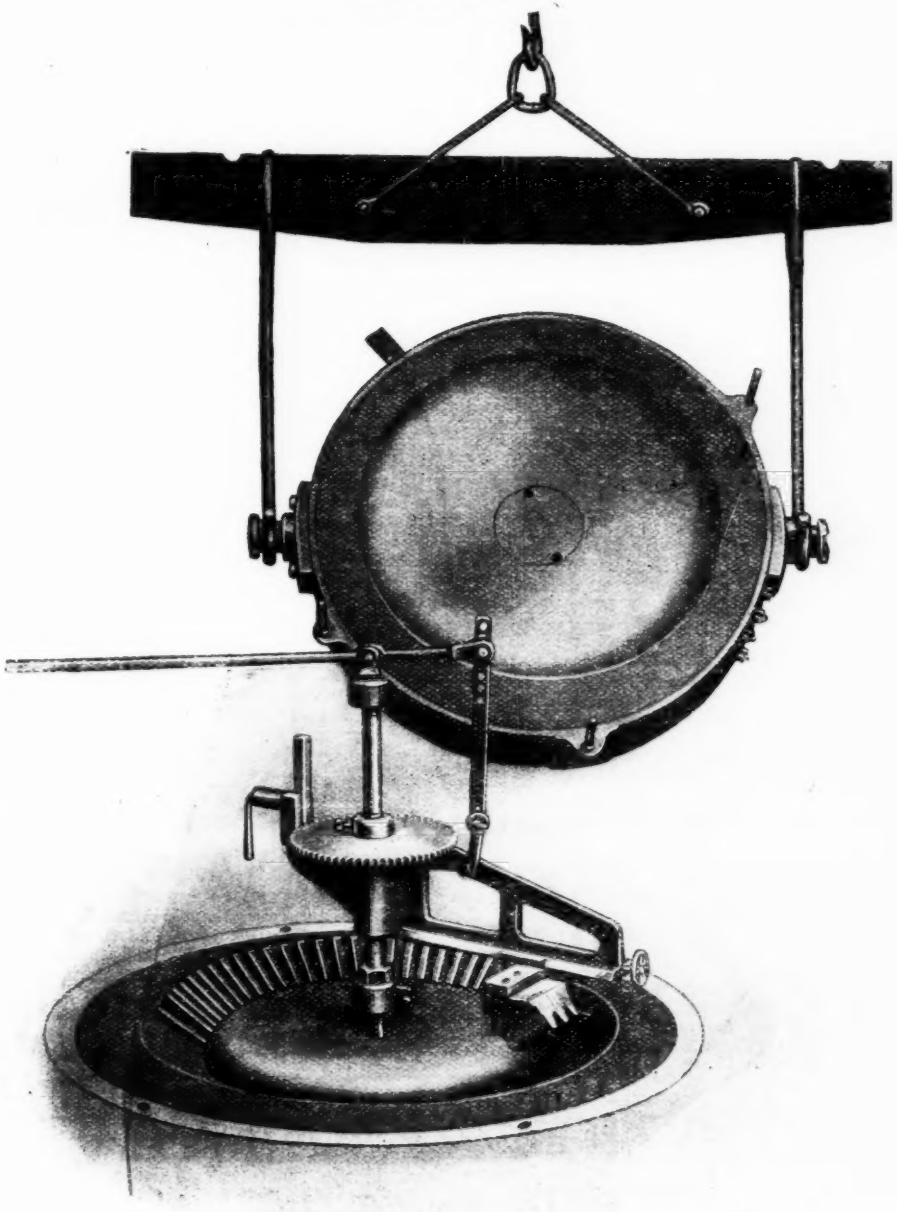
Statements that alloys of duralumin-type cannot be employed for castings and that in the cast unworked state they do not exhibit age-hardening appear in authoritative text-books on aluminium alloys, published as recently as 1921.

We now know that age-hardening can be produced in cast alloys as well as wrought, and the reason for early failures to produce age-hardening in castings becomes clear.

(To be continued.)

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS,
(MANCHESTER), LIMITED,
BLACKFRIARS, MANCHESTER.

(*Continued from page* 512.)

INCOME.

	£ s. d.
Subscriptions received	1,913 14 9
Sale of proceedings	10 0 6
Interest on War Loan and cash on deposit	30 6 8
Donation—Birmingham Chamber of Commerce	80 0 0
	£2,034 1 11

LIABILITIES.

			£ s. d.
Subscriptions paid in advance			101 11 6
Sundry creditors			320 5 8
The Oliver Stubbs Medal Fund—balance from last account	205 0 4		
Refund of tax on investment	3 9 0		
Interest to date	7 19 4		
	216 8 8		
Less: Cost of Medal, 1924	9 10 0		206 18 8
Surplus at December 31, 1923	9 10 0		
Add: Excess of income over expenditure for year ended December 31, 1924	277 7 7		999 14 6
			£1,628 10 4

ASSETS.

	£ s. d.	£ s. d.
Cash in hands of secretaries—		
Lancashire	2 15 1	
Birmingham	11 15 9	
Scottish	21 13 6	
Sheffield	77 5 0	
London	34 4 9	
East Midlands	28 18 11	
West Riding of Yorkshire	25 16 7	
Coventry	18 2 8	
Wales and Monmouth ...	7 6 0	227 18 3
General Secretary	... ...	5 16 8
Lloyds Bank, Limited—		
General account	269 19 5	
Deposit account	400 0 0	669 19 5
Oliver Stubbs Medal Fund—		
£342 5s. 7d. local loans £3 per cent. stock at cost ...	200 0 0	
Balance in hand Lloyds Lloyds Bank, Ltd. ...	6 18 8	206 18 8
Investment account—		
£100 5 per cent. National War bonds		
£350 5 per cent. War Loan at cost ...		432 10 1
Furniture, fittings and fixtures—		
Per last account	94 16 11	
Less: Depreciation 10 per cent.	9 9 8	85 7 3
		£1,628 10 4

We have prepared and audited the above balance-sheet with the books and vouchers of the Institute and certify same to be in accordance therewith.

(Signed) J. & A. W. SULLY & Co.,
Chartered Accountants, Auditors.

Diploma Winners.

THE PRESIDENT remarked that doubtless members would be interested to learn that the following gentlemen had been awarded diplomas by the Council:—Messrs. D. Wilkinson, Birmingham; J. W. Frier, Newcastle; Jowett, Lancashire; and F. C. Edwards, Birmingham.

Presentation to Mr. O. Stubbs.

THE PRESIDENT said he had now to switch on to a pleasant task, namely, that of passing on to Mr. Oliver Stubbs an illuminated address in album form as a small recognition and as a reminder of the many signal services he had rendered to the Institute and to the foundry trade in general.

MR. OLIVER STUBBS, who received quite an ovation in rising to reply, said he was deeply sensible of the honour that had been done him. Already he had received from a previous President an illuminated address in recognition of the little he had been able to do on behalf of the Institute and the foundry trade. The address in his possession was a very large one, and when the suggestion was thrown out to him that he should accept another address, he had hinted that it might take book form, so that it could be handed round to his friends. Although he had gone out of office, his interests were closely bound up with those of the Institute. Personally, he felt that was the proper spirit to promote. It was only right that those who had got the experience should continue to give the younger members the benefit of that experience. Although, as he had already remarked, he had retired from active duty as an office-bearer, he still did his very best to attend all the meetings. He noticed that all the past presidents of the Institute were not with them that morning. To his mind that was rather unfortunate, because he did think that some of the gentlemen who were absent might have got to the annual gathering. At the meeting of the Council on the previous evening something had been said about the formation of junior branches. Personally, he was a firm believer in this, that the success of the Institute entirely depended on the manner in which they looked after the interests of the younger men. He was a believer in the idea of getting hold of the young. If they treated them in the proper way and with the right measure of tact they would come out right at the finish. He was delighted to notice that two of the junior members of the Lancashire branch were with them on this occasion, and he hoped the Institute would develop along the lines of giving every possible measure of encouragement to the young men connected with the industry.

Induction of New President.

THE PRESIDENT said that the next item on the programme was, to him at all events, a very happy one. He could assure them that the Presidentship of an Institute such as theirs was no easy matter. So far as he was concerned, however, he had regarded it as a labour of love. Certainly he had rather enjoyed the work. At the same time, it was arduous, and to some extent he had pleasure in handing the duties over to his successor. He proposed, therefore, that the new President of the Institute for the ensuing year should be Mr. J. Cameron, of Kirkintilloch, the senior vice-president.

MR. F. J. COOK (past-president), Birmingham, said it afforded him pleasure to second the proposition made by their good friend, Mr. Patterson. With all due respect and reverence for those who had gone before, he was bound to say that he felt Mr. Cameron, of Kirkintilloch, would make an ideal President. He submitted his name with the greatest confidence.

The proposition was put to the meeting and carried with acclamation. Mr. Cameron was duly invested with the chain of office by Mr. Patterson.

MR. J. CAMERON, in acknowledging the honour, humorously remarked that it was only last night he began to realise the job he had taken on. Mr. Patterson and the other Presidents of the past had not taken their duties and responsibilities at all lightly. There was no doubt of this, however, that within the last four or five years the Institute had been getting a little more ambitious. As a matter of fact, it had been asking a great deal more from its President than was the case in the earlier days. They were not content now with merely a simple outing and a few papers. The social element as well as the practical and scientific aspects of the Convention had been fully developed and explored. He was conscious of his own limitations, but he yielded to none of those who had occupied the presidential chair when he spoke of the admiration he had for the Institute and its work. With the help he would get from the senior vice-president and the junior vice-president, as well as the co-operation that would come from an admirable Council, he would do his best to maintain the high traditions of the past.

MR. C. J. LAMB, who established British Engines, Limited, St. Peter's, Newcastle, died recently.

MESSRS. G. B. BIRCH, G. D. B. Birch and C. F. Dingley, brassfounders, 212 and 213, Cheapside, Birmingham, trading under the style of Birch & Company, have dissolved partnership so far as regards Mr. G. B. Birch, who retires.

Sterling

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THEY SHOW THE SHAPE OF THE SPECIAL ROLLED CHANNEL STEEL FROM WHICH ALL STERLING MOULDING BOXES ARE MADE.

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Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—While business continues quiet, conditions in the Cleveland iron market, on the whole, may be described as a shade more encouraging, the volume of inquiry of late having been on a more extended scale, both on home and export account, consumers apparently realising that nothing is to be gained by further postponing purchasing in the hope of securing better terms. Producers, at all events, are not in the mood to make any further concessions. They have practically brought down the output to the irreducible minimum, and current prices are unremunerative. They are accordingly disposed to mark time for the present and await developments. At last week's market, sellers would not quote below 74s. for No. 3 G.M.B., although some tempting offers were put forward at a shade below that figure. No. 1 was quoted at 80s., No. 4 foundry at 73s., and No. 4 forge at 72s. per ton.

A slight improvement may also be traced in the hematite section, there having been a certain amount of quiet buying on the part of Sheffield users, which is an encouraging sign. Quotations were irregular. Some makers adhere to 80s. per ton for East Coast mixed numbers, but there are sellers below this figure, and probably 79s. 6d. per ton represents an average price, with 6d. more per ton for the No. 1 quality. In the North-West area, prices are generally unchanged, Bessemer mixed numbers being 87s. 6d. c.i.f. Welsh ports, 90s. per ton delivered at Glasgow, 96s. per ton delivered at Sheffield, and 98s. per ton delivered at Birmingham.

LANCASHIRE.—The continued slackness in the local foundry trade has further decreased the demand for pig-iron in the district markets, with a consequent weakening in prices which seem inclined to still lower levels. There are some sellers of Derbyshire No. 3 iron who hold out for 82s. 6d. per ton, delivered in Manchester, but these seem now to be the exception. The market has steadily fallen from 87s. 6d. to 82s. 6d., and the final 2s. 6d. is now slowly being eaten away. Whether it will be possible to contemplate a lower level than 80s. in Manchester is, perhaps, doubtful, but there are some consumers here who are beginning to think about this possibility.

THE MIDLANDS.—In this district, the general tendency amongst consumers is not to enter into forward commitments, and one can readily understand this position with the market prices as irregular as they have been during the last month or so. The usual order at the moment is for a truck or two to carry on from time to time, very few of the ironfounders having any stock to fall back upon. Current quotations rule as follow:—Derbyshire No. 3 foundry, 72s. to 73s. 6d.; Staffordshire No. 3 foundry, 72s. 6d.; Northants, No. 3 foundry, 66s. to 67s. 6d.

SCOTLAND.—The depression so long prevailing in the local iron markets affords, at present, little indication of improvement, and with the near approach of the summer holidays, the volume of business passing is more likely to contract than expand. Consumers continue to buy only the smallest tonnages, and the price of No. 3 Scotch foundry to-day is nominally 83s. 6d. at the furnaces. No. 3 Middlesbrough is quoted at 78s. f.o.t. Grangemouth. No. 3 English iron from the Midlands is being offered at 77s. 6d. delivered works in this district, and some business has also been done in this class of iron.

Finished Iron.

The recent reductions in price of South Staffs marked bars and crown quality iron have so far had little stimulating effect upon demand for this material, for which specifications are still greatly in request by makers, with keen competition for any orders coming forward. There is still a marked disparity between the price for bolt and fencing iron, and that being quoted by the Continental works, as an iron suitable for this trade, can be purchased from that source at £7 to £7 2s. 6d. per ton delivered, and, therefore, the greater proportion of the trade emanating from the bolt makers in this area must go abroad. The marked bar makers who do not experience this hindrance are not by any means fully employed, and new business is very hard to get.

Steel.

Some idea of the actual condition of the steel trade in Sheffield may be indicated by the most recent official figures showing a drop of nearly 17,000 tons in a month. The output was 94,400 tons in March and 77,600 in April. The heavy engineering sections of local industry are not too well employed at present, but the lighter branches and tool makers have plenty of work on hand. Another item of interest in the steel market is the cut made in the price of hard basic billets by the Associated steel makers of ten shillings per ton. The new minimum price is £9, with medium at £8 10s., and soft £7 15s. These prices are, however, purely nominal, as business in soft qualities is frequently done at 20s. and even 25s. below the price named. Acid billet buying, considering all the circumstances, is on a fairly satisfactory scale. A very fair all-round business has been done in tinplates recently, the low prices tempting buyers to cover in their requirements. The recent advance in block tin has, however, caused makers to harden their quotations, and while 19s. 9d. was freely taken a week or so ago, 20s. is now being paid, and there are not many sellers at this.

Scrap.

Demand for all kinds of scrap material may be said to have almost reached the vanishing point, and at present there seems faint prospect of an early recovery in any of the markets. In the Midlands, however, cast-iron scrap is, if anything, firmer than any of the other classes of material, but merchants have difficulty in realising more than 80s., delivered for the better qualities. There is a very poor demand indeed for light cast-iron scrap, but parcels have changed hands at £3 2s. 6d. to £3 5s., delivered to works. In the Scottish markets demand for all classes of cast-iron scrap is also quiet, and machinery quality, in pieces not exceeding 1 cwt., is being offered at as low as 82s. 6d. per ton, and for ordinary cast-iron scrap to the same specification 75s. to 76s. 3d. per ton, while old cast-iron railway chairs have been disposed of at 81s. 3d. per ton. Light cast iron and firebars are a drag on the market at 60s. to 61s. per ton. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—Fluctuations in copper values during the past week have reflected a somewhat lower tone following what is, perhaps, the usual seasonal tendency of slower demand. This condition may be inferred from an increase in stocks in the past month from 44,968 tons to 46,100 tons, this total including 5,029 tons of refined and 41,071 tons of rough bar copper. The latest returns compare with 38,419 tons at the end of December last and 31,030 tons at the end of 1923. These stocks are more than treble those of three years ago. Current quotations :—*Cash* : Thursday, £59 5s.; Friday, £59 10s.; Monday, £60 5s.; Tuesday, £60 10s.; Wednesday, £60 5s.

Three Months : Thursday, £60 5s.; Friday, £60 10s.; Monday, £61 5s.; Tuesday, £61 7s. 6d.; Wednesday, £61 5s.

Tin.—Movements in this section of the metal market disclose a firmer tendency, although without much difference on balance. The statistical position shows an increase in the visible supply of 2,500 tons. This increase was rather heavier than was anticipated, but had little effect on prices. For the moment opposing interests are less active. The strong support which has been the feature of the last month has been withheld, while the depressing tactics of the opposition have been less noticeable. Current quotations :—*Cash* : Thursday, £252; Friday, £251 5s.; Monday, £253; Tuesday, £254 17s. 6d.; Wednesday, £252 10s.

Three Months : Thursday, £253 5s.; Friday, £252 7s. 6d.; Monday, £254; Tuesday, £256; Wednesday, £254.

Spelter.—With a fair general inquiry, values of this metal remain fairly steady. Henry Gardiner & Company write that, so far, the month has witnessed a little more interest from some of the large consumers in this country, and in face of the stiffer attitude of American producers noted recently, the London market has remained firm. Inquiry appears to be on the increase, and on the extent of this feature depends the course of prices in the immediate future. Current quotations :—*Ordinary* : Thursday, £34 1s. 3d.; Friday, £33 17s. 6d.; Monday, £34 7s. 6d.; Tuesday, £34 7s. 6d.; Wednesday, £34 3s. 9d.

Lead.—The market for soft foreign pig continues firm under the influence of consistent German interest, supplies in this country remain ample, and temporarily are rather more than consumption can absorb. Cable makers have bought a good tonnage at full prices for future arrival, and Continental buying is also in evidence, while America remains firm, although the price there has eased under the best. *Soft foreign (prompt)* : Thursday, £33 7s. 6d.; Friday, £32 18s. 9d.; Monday, £33 7s. 6d.; Tuesday, £33 8s. 9d.; Wednesday, £33 12s. 6d.